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BASIC RESULTS OF THE MEDICAL RESEARCH CONDUCTED DURING THE FLIGHT OF TWO CREWS ON THE SALYUT-5 ORBITAL STATION

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16. Abstract
The study of the effect of space factors, especially weightlessness, on man, taking into account prophylactic measures and devices to counteract that effect was part of the program for 2 flights on the Salyut-5 orbital station. Information from the equipment on board was transmitted telemetrically including: an electrocardiogram; a sphygmogram of carotid and femoral arteries; a kinetocardiogram; a tacho-oscillogram of the humeral artery, perimetric oscillations of the femur, venous pulse and pressure in the jugular veins, vital capacity of the lungs, respiration rate and lung ventilation. Stress factors, metabolism, biological and bacteriological and other tests were included. A comparison was made between these data and pre and postflight test results.

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Translator's Notation: Abbreviations and acronyms used in the text

AMo -- Mode amplitude
AOP -- Antiorthostatic position
AP -- Arterial pressure
CDR -- Commander
DI -- [Diastolic index][1]
FCC -- Frequency of cardiac contractions
HP -- Horizontal position
IE -- Isoenzyme
IIOS -- Integral index of orthostatic stability
IPS -- Inflatable prophylactic suit
LBNP -- Lower body negative pressure
LDH -- Lactic dehydrogenase
MV -- Minute volume
OBE -- On-board engineer
OP -- Oxygen pulse
OPS -- Orbital planetary station
OS -- Orthostatic stability
PC -- Phosphocreatinase
PE -- Expulsion period
PFPS -- Postflight prophylactic suit
REG -- Rheoencephalograph
RPPW -- Rate of propagation of the pulse wave
RR -- Respiration rate
SDH -- Sorbitodehydrogenase
SI -- Stroke index
SPR -- Specific peripheral resistance
StI -- Stress index
SVI -- [Stroke volume index]
SyI -- [Systolic index]
VCO_2 -- Volume of CO_2

Ve -- Elastic vessels
Vm -- Muscular vessels
VO_2 -- O_2 requirement

[1] [ ] indicate that the acronym was not defined in the text or in reference materials, but probably stands for that term.

BASIC RESULTS OF THE MEDICAL RESEARCH CONDUCTED DURING THE FLIGHT OF TWO CREWS ON THE SALYUT-5 ORBITAL STATION

Anonymous

According to the Soviet program for mastery of near-earth cosmic space in 1966-77, flights of two crews were made on the Salyut-5 orbital station: /1*

- from July 6 to August 24, 1976, a 49-day flight of a crew made up of crew commander B.V. Volynov and on-board engineer V.M. Zholobov;

- from February 8 to 26, 1977 - an 18-day flight of the crew made up of commander V.V. Gorbatko and on-board engineer Yu.N. Glazkov.

The program of both flights had a broad scientific character. It was set up with a large number of varying experiments intended to solve scientific and national economy problems. One of the sections of this program was the study of the effect on man's organism of factors of space flight taking into account the use of a complex of measures directed at preventing the adverse effects of weightlessness.

The arsenal of devices and methods used in the Soviet space programs for prophylaxis of adverse changes in the organism due to weightlessness as one of the leading physical factors of space flight, is basically defined at the present time. These devices and methods have already been used earlier with a positive effect during preceding flights on the Salyut type orbital stations.

On the Salyut-5 station, a complex of devices and methods indicated included:

- a complex training mock-up for physical exercises ("a running track," a collection of spandrel frames, a system for creating axial load, etc.);

- load suits for constant wearing; /2

- vacuum capacity for creating negative pressure on the lower half of the body;

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*Numbers in the margin indicate pagination in the foreign text.

- on-board first aid kit;

- post flight prophylactic suit (PFPS).

Daily operative medical control and periodic medical examinations and studies are planned for the program of medical supervision of these flights as for flights on other orbital Salyut type stations.

Operative (current) medical control for the general condition and state of health of the cosmonauts is accomplished using telemetric methods, and also on the basis of data of radio exchange and televised observations. The following were transmitted to the ground measuring posts: electrocardiograms at D-S contact point (side-side), seismocardiograms, breathing rate and temperature of the body (submuscular). According to the program, both cosmonauts had to be constantly hooked up to the equipment continuously during the first three days of flight; later on, the cosmonauts were attached to the apparatus in turn each day, once in 24 hours. Moreover, daily, usually before sleeping, the crew transmitted to Earth a brief report for the preceding day as to their state of health, sleep, appetite, elimination functions, and also data on pulse rate and the size of arterial pressure (measured by the cosmonauts themselves using an ordinary clinical sphygmomanometer).

The periodic medical examinations envisaged recording a broader spectrum of physiological indices, both in the state of operative rest, and during different types of measured load tests. As a rule, these examinations were carried out at the same time of day as in the preflight. For a detailed study of the state of the cardiorespiratory system, an on-board apparatus, the Polinom 2-[letters illegible in the text] apparatus was used which made it possible to transmit telemetrically the electrocardiogram with 12 contact points, a sphygmogram of carotid and femoral arteries, a kinetocardiogram, a tacho-oscillogram of the humeral artery, perimetric oscillations of the femur, venous pulse and pressure in the jugular veins, vital capacity of the lungs, respiration rate, breathing volume and breathing minute volume (lung ventilation). /3

Rheographic studies were conducted using a Levkoy apparatus: a rheo-encephalogram, a rheopneumogram.

The following were used as load test effects:

- physical load in the form of a 4-minute run on the "running track" at a rate of 150-160 steps per minute;

- negative pressure on the lower half of the body (LBNP) at a size of 25 mm mercury column for 2 minutes and 35 mm mercury column

for 3 minutes.

Moreover, the program of scientific and medical research envisaged periodic:

- taking and saving of a sample of capillary blood (from the palm) for subsequent analysis in ground conditions (postflight);

- measurements of the body mass on the on-board instrument with telemetrically transmitted indices to Earth;

- determining taste sensitivity and the pH of the saliva; and also conduct of certain psychophysiological studies.

In this way, the volume of medical observation and medical research made it possible to discover changes occurring in the organism of the cosmonauts due to physical factors of flight and the complex on-board devices made it possible to correct these changes.

Preventing possible adverse changes in the general condition and general work capability of the crew was accomplished [words illegible in the original text], regulated regime of work, rest and eating periods. /4

The planned schedule for the station envisaged:

- an 8-hour uninterrupted sleep for both members of the crew at the same time;

- self-service operations - 8 hours including:

physical training	-	2 hours 30 minutes
taking nourisment	-	2 hours 15 minutes
personal hygiene	-	30 minutes
personal time	-	2 hours 45 minutes

- work - 8 hours.

In accordance with medical recommendations directed at maintaining high work capability of the crewmembers and timely restoration of strength after stressful activity, the time devoted to controlling the spacecraft and its systems, carrying out various experiments and observations (including the medical research) and each professional activity, that is, the total budget of working time amounted to from 42 to 48 hours a week with one free day. This free day or rest day for the cosmonaut made it possible for him to do as he pleased except for operations necessary for

maintaining the work capability of the station and certain medical studies.

Comfortable conditions for living and work of the cosmonauts were maintained for the entire flight on the station.

The hygienic parameters of the station atmosphere were:

- total barometric pressure P_{tot} - 830 - 870 mm mercury column
- partial pressure of oxygen pO_2 - 169 - 210 mm mercury column
- partial pressure of carbon-dioxide pCO_2 - 1.1 - 9.6 mm mercury column
- humidity - 6.5 - 11.5 mm mercury column
- air temperature - 16° - 26°

In accordance with the results of preceding flights, the caloric intake for the daily ration was reduced to 3000 kcal (2900 - 3100 kcal). Six variations of the daily menu are planned /5 besides the previous four and also reheating was introduced not only for the food tubes and cans but also for the bread; both crews considered this an advantage. According to the wishes of the crew, seasonings of a type of spicy sauce were introduced. They also received a positive evaluation from the cosmonauts.

General Results of the Flight

Carrying Out of the Schedule of the Day

In order to correctly interpret the medical data obtained in the flight and in the postflight period, and also in order to understand the evaluation of the flight by the cosmonauts themslves, it is necessary first of all to know how the cosmonauts worked, that is, to consider the workload of the crew in flight, the planned schedule of the day carried out by them.

One should note that both crews in the initial flight period had difficulties in carrying out the work and rest regime intended before the flight. This involved an increase in time; actually, the time expended by the crews on certain work operations, in comparison with that planned, was increased in the first days of flight in the period of initial adaptation to weightlessness. However, the crews themselves had a noticeable adjustment in fulfilling both the planned obligatory operations and experiments and also the additional reserve operations. Attempting by all possible means to fulfill and sometimes to overfulfill the full program of work resulted in the fact that the crews cut down on

eating time, rest, physical training and even sleep. On some days, the work load of the crews amounted to 13-14 hours; then they also used their personal time which had been set aside according to the schedule for rest, and the free days planned for them were used only partially.

Distribution of time between the basic parts of the work and rest regime and the relationship between the planned and actual time expended are shown in Figures 1 and 2. /6

Insufficient sleep is particularly characteristic of the first crew (Volynov-Zholobov) where the total deficit of sleep for the flight amounted to about 90 hours for each cosmonaut. This apparently also involved the psychological characteristics of the spacecraft commander who possibly made too detailed testing of the condition of the station, making it necessary for him and his flight engineer to lose even more sleep, naturally.

In order to have more time for work, the cosmonauts often put part of their 24-hour food ration in their pockets and ate directly at the work location not interrupting observations and recordings.

Unfortunately, the "savings" in time also cut into the physical training time. This applied particularly to the second crew (Gorbatko-Glazkov) who "expended" their strength on a relatively short flight. They used only 50% of the planned time for physical training.

Work in such a regime, with such high efficiency provided successful completion of the flight program; however, in a definite way it affected the state of health and functional state of the cosmonauts. Noticeable changes in well-being (especially the appearance of feelings of fatigue) and objective shifts in the functional state of the crewmembers had a very clear direct connection to the intensity of preceding activity.

On the whole, the crews themselves understood this. After completion of a flight, the commander and the on-board engineer of the second crew (CDR-2 and OBE-2) unanimously estimated that they could have operated perhaps only for 7-10 days in such a regime. No wonder, in distinction from the first crew, they began to notice fatigue at the end of the working day even in the second day of flight (the first crew - only after a week). /9

Evaluations of Flight by the Crews

The cosmonauts almost uniformly and very similarly to their predecessors described transition to weightlessness and the period of initial adaptation. Each one, of course, had his own peculiarities.

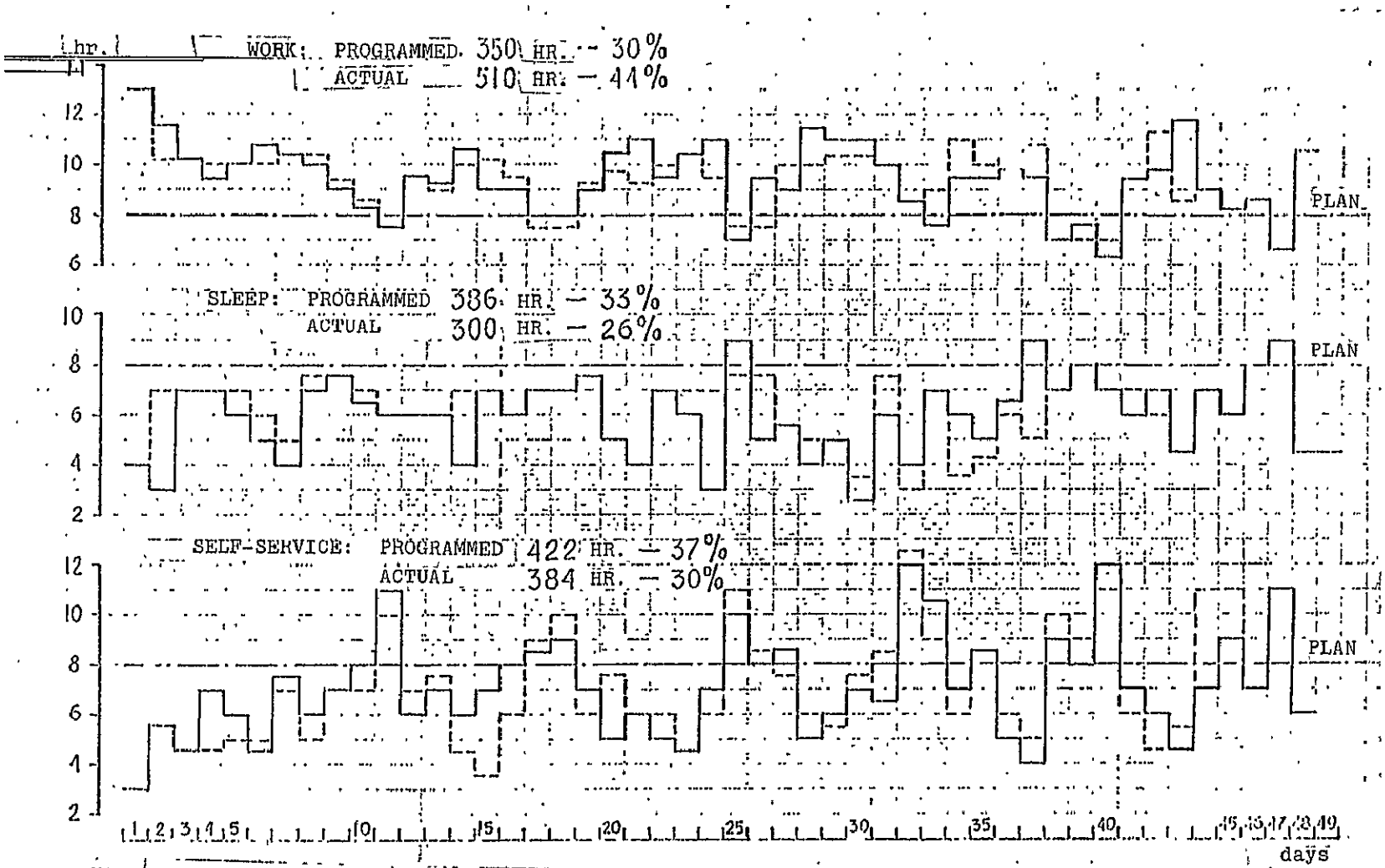

Figure 1. Distribution of time among the basic program elements for the crew of the Soyuz-21--Salyut-5 (total flight time--1158 hours - 100%).

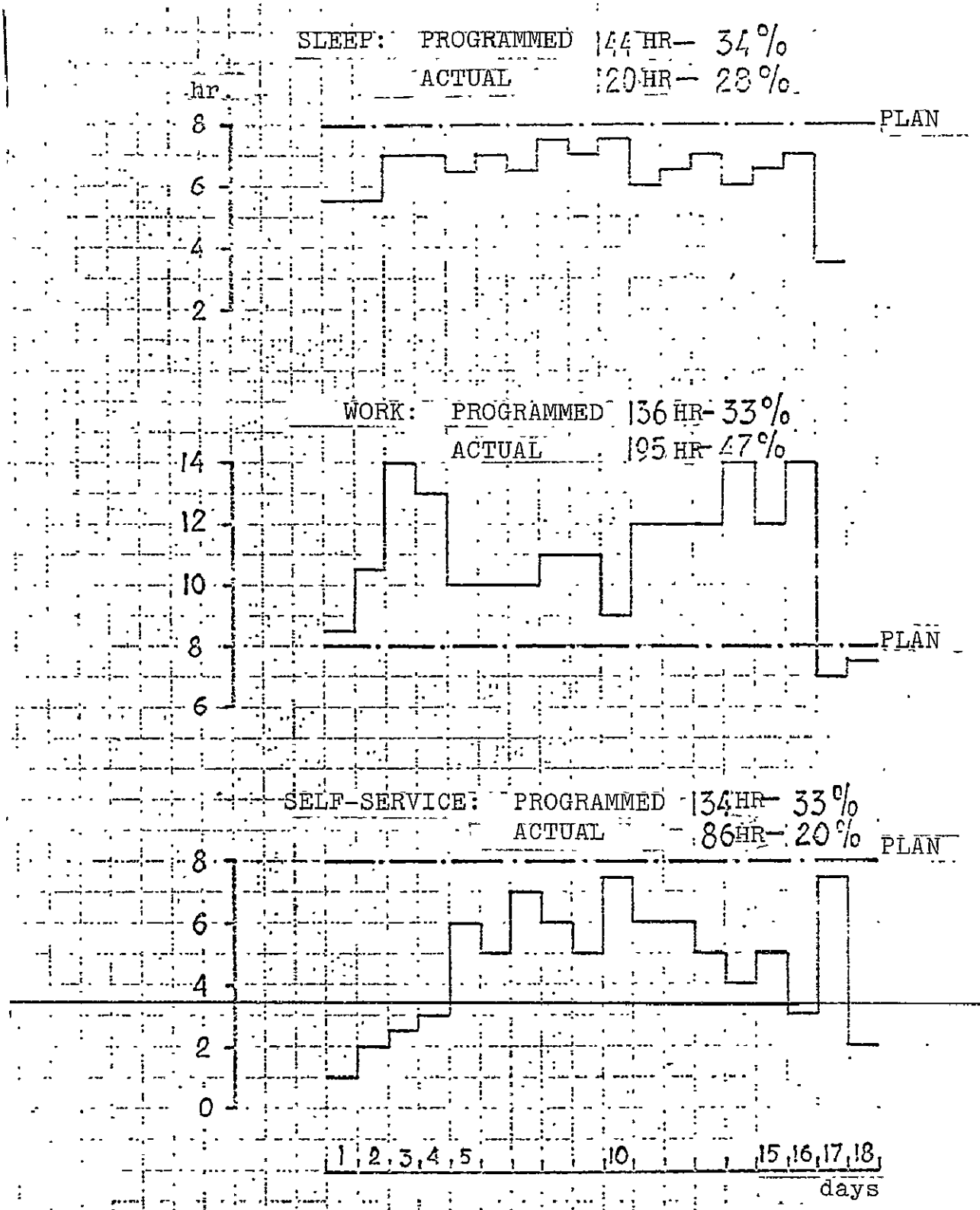

Figure 2.— Diagram of distribution of time for the crew of the Soyuz-24—Salyut-5 according to the basic element of the program when making a space flight.
Total flight time— 414 hr.

Thus, although vestibular dysfunctions, symptoms of motion or rocking sickness did not occur in one of the four, both members of the first crew during transition to weightlessness noted the illusion of perceiving change in position. The CDR-1 felt as if "there was a backwards somersault, then the spacecraft (Soyuz) flew in an inverted position; when looking out the porthole at Earth, the illusion of the inverted position disappeared." For the on-board engineer (OBE-1) when going into orbit, "the craft sloped forward at 90°."

It is interesting that the illusions mentioned created a certain amount of difficulty for the crew with manual docking and joining to the station in such a way that it was like the first flights on an airplane in clouds or fog.

The impression is created that, as in other flights, in this case a mutual induction of the crewmembers or a group reaction occurred: both members of the first crew underwent a short-term loss of orientation when transferring from the transport craft to the station and the reverse. The CDR-1 explains this by the fact that on the station "below," the "floor" was located along the length of the axis whereas in the transport spacecraft "below" was perpendicular to it. Therefore, "surfacing" from the launch apparatus of the transport spacecraft "upward" through the orbital section and transition lock to the station, the cosmonaut suddenly seems to be "swimming" over the "floor" of the station, that is, /10 everything has turned by 90°.

It is necessary to point out that earlier such an effect, although less clear, was described only by members of the first crew of the Salyut-4 station, Gubarev and Grechko. But they (and again both of them) perceived a similar vestibular dysfunction only when transferring from the station to the transport spacecraft and this did not occur at all with the reverse transfer.

The second crew OPS of the Salyut-5 (Gorbatko-Glazkov) did not note such illusions.

Both crews, like many other cosmonauts, perceived a rush of blood to the head. The clarity and length of this sensation differed in different cosmonauts.

CDR-1 perceived the rush of blood to the head only weakly, although redness of the face and bulging of the face veins, neck and upper part of the chest was noted. A rush of blood was not accompanied by a headache and did not affect work. The cosmonaut complained only of stuffiness of the nose and slight rhinitis; however, these manifestations may be more due to a slight cold from the ventilator than from the rush of blood.

OBE-1 noted a definite rush of blood to the head, which he began to perceive after 4-5 hours after going into orbit and it gradually increased reaching a maximum on the second day. He had a slight headache. Gradually, the feeling of the head being too full began to slacken and by the fifth day, the cosmonaut stopped noticing it.

In members of the second crew on the other hand, the rush of blood to the head was accompanied by a feeling of "heaviness," and also a headache. These perceptions and the headache lasted fairly long but at the end of the first week they were used to it and stopped giving it attention. Edema of the face and neck was very obvious, especially if one considers that both cosmonauts are round faced and not distinguished by leanness. /11

All of the cosmonauts both in the first and in the second expeditions complained of the dryness of the air. Particularly unpleasant was the sensation of dryness in the nose. The skin became rough. After the flight, the cosmonauts observed a degree of hyperkeratosis during 5-7 days; because of this, removal of thickened sections of skin occurred.

The period of initial adaptation to weightlessness was characterized also by a certain discoordination of motion as had been observed in all preceding flights. Proportioning of effort, coordination of motions with variables were salvaged at the end of the first week of flight.

As was already indicated in both crewmembers, a lack of sleep was noted particularly in the first crew. CDR-1 slept 2-4 hours on certain days. In truth, in these cases he attempted to cut down the time in sleep 1-1.5 hours per day. The sleep usually was very refreshing, the head became clear, fatigue disappeared, and work capability increased.

As to appetite, it remained good in all the cosmonauts. In truth, the first crew noted a change in taste: they stopped eating cheese, its odor irritated them. Moreover, with the development of fatigue at the end of the flight, the appetite of OBE-1 decreased. The food, in general, was satisfying although after intense work and after a good workout on the physical training unit, the crew sometimes added somewhat to the ration from the reserve supplies. In spite of a sensation of dryness in the mouth, not one cosmonaut suffered from thirst, but drank water as usual. /12

The natural elimination functions in all the cosmonauts were regular and caused no difficulties. The stool was usually daily, urine elimination was 4-6 times in 24 hours. Only OBE-2, on the first and second days of flight, was worried that possibly the stool was hard and took a preventative laxative.

Medications were used as needed: for a headache (Analgin, sometimes Bromedole), small injuries, inflammation around the nails (Oxycort ointment), sleep disorders during fatigue (Phenybut, Eunoctin). The use of Etaminal-sodium by the commander of the first crew has already been noted.

Results of Medical Studies

According to the data of operative medical control, changes in the rate of cardiac contractions and elements of the EKG complex at D-S point of contact, corresponded both to observations made in preceding flights and to peculiarities inherent in the cosmonauts and noted in preflight examinations.

The commander of the first crew, B.V. Volynov (CDR-1): horizontal axis of the heart, episodic singular extrasystoles at rest.

The on-board engineer of the first crew, V.M. Zholobov (OBE-1): bradycardia, increase in the time of intra-gastric conductivity to 0.11-0.12 s, calcification of the papilla of the calices of the right kidney (X-ray discovery) without clinical manifestations and without a disturbance of the kidney function.

The commander of the second crew, V.V. Gorbatko (CDR-2): transitory decrease of the S-T segment and the T wave on the EKG without clinical manifestations and negative dynamics, occasional singular extrasystoles at rest, thickening of mucosa of the walls of both maxillary sinuses without clinical manifestations.

The on-board engineer of the second crew Yu.N. Glazkov (OBE-2): /13 single, occasional extrasystoles at rest.

On the active part of the flight, maximum values of pulse rate were: CRD-1 - 100, OBE-1 - 108, CDR-2 - 132, OBE-2 - 84B/min.

In flight, significant variations in amplitude of the T wave were observed in the CDR-2; sometimes at the end of the day, it decreased becoming 15-17 times smaller than the R wave. Similar manifestations in him occurred before flight and in flight; the variations in size became somewhat greater. It is possible that this was due to the development of compensatory fatigue at the end of the working day.

In the OBE-2, in flight, as in the preflight period, occasionally single extrasystoles were recorded - 3 in the first week of flight and 9 in the next 10 days.

According to the data of statistical processing of dynamic series of R-R intervals (not less than 100 intervals in each block),

characteristic histograms were analyzed: Mode (Mo), amplitude of the mode (AMo), variational peak-to-peak value (ΔX) and stress index ($SI = \frac{AMo}{2\Delta XMO}$).

The high values of the SI which indicate an increase in stress of regulatory mechanisms, were noted in the section of introducing and fulfilling important dynamic operations (approach and docking). The SI values increased also in the evening hours which attested to the stress state of physiological functions and supported statements by the cosmonauts as to feelings of fatigue appearing at the end of the working day.

Periodic more intense examinations of the cardiovascular system and blood circulation as a whole made it possible to evaluate changes occurring in them in more detail. /14

During most of the examinations of both crews in flight, the final and lateral systolic arterial pressure was higher than preflight by 15-20 mm mercury column (Table 1). In the OBE-1 and OBE-2, also an increase was noted in the mean dynamic pressure at 10-12 mm mercury column.

As it was reported earlier, including in the periodic scientific press, arterial pressure in the crewmembers of the orbital stations of the Salyut type, after a period of initial adaptation, normalized fairly rapidly. Its retention at an increased level during the entire flight for the crew of the Salyut-5 station, should be re-evaluated as a result of high work and emotional stress.

Indices of stroke (SV) and minute (MV) volumes of blood were maintained in flight at the level of maximum preflight values or even somewhat exceeded them. Then, the rate of cardiac contractions in CDR-1 and CDR-2 changed within the limits of preflight values. The FCC increased somewhat in the CDR-1 in 28 days, when a worsening of his condition was observed which was indicated by the MV size.

In the OBE-1, obviously, due to the gradual asthenia of the FCC on the second half of the flight, his ordinary indices became noticeably higher.

The rate of propagation of the pulse wave in the aorta (RPPW), as a whole, also had a tendency to increase. This is especially noticeable in the OBE-1.

Changes in blood pressure in the jugular vein are very interesting; this, in the opinion of the researchers, must be an objective index of redistribution of blood in the upper half of the body, an index of the uneven filling of the head with blood, which all the

TABLE 11. [Word illegible in original] INDICES OF BLOOD CIRCULATION IN THE FIRST AND SECOND CREWS OF THE ORBITAL SALYUT-5 STATION.

CREW MEMBER	CONDITIONS OF THE EXAMINATION		FCC beats/min.	ARTERIAL PRESSURE mm mercury column				RPPW m/s	SV ml	MV l
				min.	mid.	lat.	limb			
CDR-1	PRE-FLIGHT	FOR 30 DAYS	54	53	81	103	129	6.8	103	5.6
		FOR 5 DAYS	51	59	85	101	127	4.5	150	7.7
	IN-FLIGHT	6 DAYS	47	54	96	119	146	6.3	157	7.3
		14 DAYS	50	70	96	132	153	6.9	135	6.7
		16 DAYS	48	63	94	125	140	6.1	160	7.4
		28 DAYS	56	65	96	126	148	6.5	145	8.1
		44 DAYS	53	67	92	121	147	7.0	118	6.3
OBE-1	PRE-FLIGHT	FOR 30 DAYS	43	54	82	99	122	5.1	124	5.3
		FOR 5 DAYS	42	46	71	87	104	4.5	136	5.7
	IN-FLIGHT	6 DAYS	40	48	75	109	131	6.5	138	5.5
		7 DAYS	41	48	72	100	132	6.6	121	5.0
		13 DAYS	41	51	87	110	137	6.3	134	5.5
		21 DAYS	55	48	-	98	130	6.0	128	7.0
		28 DAYS	51	50	80	106	140	5.8	137	7.0
		40 DAYS	53	42	75	100	122	5.2	166	8.8
		43 DAYS	58	57	79	108	132	6.1	121	7.0
CDR-2	PRE-FLIGHT	FOR 35 DAYS	63	62	96	106	131	6.8	86	5.4
		FOR 3 DAYS	78	69	94	108	146	6.3	83	6.5
	IN-FLIGHT	13 DAYS	69	62	92	109	151	6.2	106	7.3
OBE-2	PRE-FLIGHT	FOR 35 DAYS	48	56	86	101	126	5.3	116	5.5
		FOR 5 DAYS	55	58	86	98	134	5.6	99	5.45
	IN-FLIGHT	8 DAYS	67	60	100	110	120	-	-	-
		12 DAYS	74	57	100	115	147	-	-	-

cosmonauts talked about. As was reported earlier, in the second crew of the Salyut-4 orbital station, (Klimuk-Sevast'yanov), blood /16
pressure in the jugular vein at 43--44 days of flight, was normalized to a considerable degree and in certain studies it was somewhat lower than the initial. In distinction from these, in the CDR-1 and particularly in the OBE-1, venous pressure remained elevated for the extent of the entire flight. In the second crew, filling of the jugular veins with blood and the pressure in them was also increased, but, it is necessary to take into consideration that the length of their flight was considerably less than the time period when most data noted the appearance of fairly complete adaptation to weightlessness.

The appearance of venous stasis in the base of the head was noted in the first crew also, according to the data of focussed rheography with positioning of the electrodes at the fronto-occipital projection. Then, the venous components of the rheogram of the CDR-1 at 46 days of flight, were less clear than at 17 days. In the OBE-1, on the other hand, at 45 days, they increased in comparison with 25 days.

One should note, that in distinction from the CDR-1, in whom, according to the head rheogram, an increase in tonus of the arterial vessels was observed, in the OBE-1, the tonus of arterial vessels of the head at the end of the flight decreased significantly. The decrease in arterial tonus, in combination with the size of venous stasis noted above, is considered less favorable. At the same time, in this period, he began to have headaches.

With a complete electrocardiographic examination, at 19 days of flight, in the CDR-1 at the left chest contact points (Y_4-Y_6) a shift in the ST segment was observed below the isoline at 0.5-0.8 mm, and also flattening of the T wave which acquired a symmetrical shape. These changes, apparently, can be reevaluated as signs of metabolic disturbance of the myocardium. From the 26th to the 31st days, the changes indicated became more noticeable. We recall that approximately in this period, the CDR-1 noted worsening of his feelings of well-being and undesirible sensations in the heart region. The dynamics of the EKG in the CDR-1 made it possible to [words illegible in the original text] so /17
that he began to develop [word illegible in the original] changes in the myocardium at the end of the flight, although the clarity of their expression was very insignificant.

Electrocardiograms of the members of the second crew hardly differed from their preflight electrocardiograms.

A functional sample with the creation of negative pressure on the lower half of the body (LBNP), in the opinion of the

cosmonauts, transferred well in flight; however, members of the second crew evaluated the effect of LBNP as stronger than that on Earth.

Reactions of the cardiovascular system to LBNP in the CDR-1 and CDR-2 were average: the pulse rate increased maximally by 22%, the stroke volume decreased by 39%, arterial pressure was hardly changes (see Tables 18, 20).

In the OBE-1, a sharp decrease in transferability of this sample was noted especially at the end of flight. The rate of cardiac contractions at the time of LBNP in him exceeded the initial by 64%, and the systolic ejection decreased by 63% (see Table 19).

In the OBE-2, reactions to LBNP at 12 days of flight also was clear: the FCC increased by 45%, a decrease in peripheral resistance of the blood vessels and the rate of propagation of the pulse wave according to the aorta was observed (see Table 21).

Studies of the physical work capability (4-minute run on the "running track" at a rate of 160--[word illegible] steps per minute) showed that in the first crew, it was maintained at an adequate level and as the length of flight increased, it did not change significantly. Only at 40 days, in the OBE-1, did one observe signs of a decrease in physical work capability; immediately after running, the rate of cardiac contractions increased by 87%, and the systolic ejections decreased sharply.

Apparently, also reactions to load tests (LBNP and tests with the physical load), in the OBE-1, there was evidence of a gradually increasing asthenia due to the factors and conditions of flight. /18

Biochemical studies of blood samples taken during flight and returned to Earth supported the increase in concentrations of urea in the blood observed in previous flights. Changes on the part of the phosphorous fractions of the whole blood were noticeable which can be considered as an indirect indication of unchangeability of the content in the blood of 2,3-phosphoglyceric acid, which has considerable meaning for providing a normal function of the hemoglobin.

Changes in the uniform elements (with ordinary microscopy) and also changes in the blood formula were not observed.

On the orbital Salyut-5 station, first in the Soviet Union, an experiment was carried out in studying the dynamics of change of body weight in space flight.

From the data presented in Table 2, it follows that the

basic loss of body weight, as was true for the American astronauts, develops in the initial stage of space flight; after this, the indices of body weight are maintained at a fairly stable level. Clearer changes in body weight in members of the first crew are, obviously, one of the manifestations of asthenia which developed on a background of fatigue and lack of sleep. Due to the frequent manifestation of headaches in the on-board engineer at the end of the flight, his appetite decreased which also was expressed in a change in body weight.

TABLE 2. DECREASE IN BODY WEIGHT IN FLIGHT (KG)

Crewmembers	Days of flight							
	4	7	13	17	21	30	34	45
CDR-1	-	-	-5.34	-	-4.57	-	-6.19	-6.95
OBE-1	-	-	-2.94	-	-3.2	-2.75	-2.69	-4.42
CDR-2	-1.61	-2.11	-2.67	-2.6				
OBE-2	-2.24	-2.81	-2.59					

An analysis of results of experiments in studying sensitivity /19
of the vestibular apparatus to pulse galvanic current showed that in all the cosmonauts this sensitivity decreases in flight. Taste sensitivity of the tongue was practically unchanged which is supported by the opinions of the cosmonauts as to the food rations and drinking water (evaluations were not made preflight).

Completing presentation of medical data of the observations and studies in flight, one should note certain psychological nuances. As has already been pointed out, the crews worked with high efficiency which could lead and actually did lead to fatigue. On such a work background, there had to be high stress and therefore the least disorder of the equipment or imprecision in ground control of the flight caused greater reactions although the cosmonauts attempted to "stay in the framework."

As a result of peculiarities of the sensory background, the monotonous character of the external medium and ecological factors, a compensatory increase in sensitivity to sensory and ecological factors develops (one blows here, there is a noise there, tepid water, uncomfortable attachment, unpleasant color, etc.).

An attempt to solve this conflict situation is carried out by increasing radio exchange with Earth, particularly in transmitting a mass of questions to the control group ("so that those on Earth can also rack their brains," or "in order to inform everyone that it is getting light"). In the first crew, toward the end of the flight, an increased sensitiviey was apparent toward evaluation of their work, clear expectation of approval,

praise, and also the desire to complain, "cry on someone's shoulder," although these complaints were presented in a joking manner. At the end of the working day, hypochondric features were apparent. All of this indicated an accumulation of fatigue and the proximity of exhaustion. /20

Results of Postflight Examinations

The landing of the first crew occurred at night. Before arrival of the search group, the cosmonauts themselves, although with considerable difficulty, got out of the spacecraft, not blowing up their prophylactic suits (IPS). During examination by a doctor of the search group (after 40 minutes) they complained of pronounced weakness, could stand with difficulty only with an inflated IPS. They ate and drank with satisfaction.

The pulse rate immediately on encounter was: CDR-1--96, OBE-1--146, after a 10-minute rests lying down--84 and 86, and in the helicopter going to the base--80 and 84 beats/min; arterial pressure was 150/105 and 110/90 mm mercury column, respectively.

The second crew left the spacecraft also independently and also without using the IPS. During examination at the spacecraft, the pulse rate of the CDR-2 was 98, of the OBE-2--96 beats/min; arterial pressure lying down was 110/70 and 115/75 mm mercury column; submuscular temperature was 37.0° and 36.1°, respectively. Thirst was average.

During examination at the cosmodrome, symptoms of asthenia and fatigue more marked than in the first crew was noted in all the cosmonauts. There was a decrease in the perimeters of the thigh and shin and a large loss of weight (more than any of the other Soviet cosmonauts) in the CDR-1 and OBE-1 (Table 3).

TABLE 3. CHANGE IN BODY WEIGHT AFTER FLIGHT /21

Crew member	Pre-flight	Deficit on day of landing		Dynamics of weight postflight			
		kg	%	0	4	14	30
CDR-1	78.8	7.3	10.0	71.5	75.5	77.0	78.4
OBE-1	77.0	6.6	9.1	70.4	74.2	75.0	76.9
CDR-2	76.0	3.5	4.6	72.5	74.7	75.5	78.5
OBE-2	65.3	3.9	6.0	61.4	62.8	63.3	64.7

Recovery time for these indices was, as a rule: fairly rapid increase in the first three days postflight and then a slower recovery. By the 14th day, only the CDR-2 had regained

his weight and by day 30 he even exceeded it by 2.5 kg. In the other cosmonauts, after 14 days, the weight deficit still amounted /22
to from 1.5 to 2.0 kg (OBE-2) and on the 30th day only the OBE-2 had not regained his weight (specially limited diet).

The dynamics for recovery of the perimeters of the thigh and shin were similar: on the 14th day, the deficit amounted to 0.5--1.0 cm in the second crew and 3.0--1.5 cm in the first; by the 30th day, the size of the perimeters had practically regained preflight values and sometimes even exceeded them by 0.2--0.6 cm (OBE-2 and CDR-2).

As has been indicated more than once, such a character of change and recovery of weight and perimeters of the lower extremities indicates that the decrease in weight in flight comes, basically, from loss of water; however atrophic changes of the muscles are important. The latter once again point out the inadequacy of physical load onboard, especially for leg muscles inasmuch as the muscles of the arms have a fairly good load and their characteristics are almost unchanged (Table 4).

It is natural that as in preceding flights, a good deal of attention was turned to a detailed study of the condition of the cardiovascular system.

The general characteristics of frequency of cardiac contractions and arterial pressure at rest with therapeutic examinations after flight are presented in Table 5.

As is apparent from the Table, in the CDR-1, in the first days, obvious hypertension was observed; however, he was the only one capable of standing without the BPS immediately after the flight. The other cosmonauts, in the first hours after landing, could not sit for long much less stand (although they could walk without assistance). Recovery of the indices occurred spasmodically and on the 14th day they had practically returned to preflight levels; however, a certain instability, lability both in pulse and in arterial pressure was observed up to 30 days and possibly longer.

Study of the systemic blood circulation makes it possible /24
to evaluated in more detail a series of indices which characterize the state of the cardiovascular system. The data of this examination presented in Tables 6 and 7 indicate that after flight, in members of the first crew, all of the parameters of arterial pressure were increased including such a stable parameter as mean dynamic pressure (AP_m); the tonus of the elastic and muscle-type vessels (V_m and V_e) and specific peripheral resistance (SPR) were increased. At the same time, cardiac ejection (stroke index--SI) decreased and the period of expulsion (PE) shortened significantly.

TABLE 4. CHANGE IN PERIMETERS OF THE THIGH, SHIN AND SHOULDER /21

Crew member	Part of the body	Preflight (cm)	Dynamics of the perimeter in postflight days in cm			
			0	4	14	30
CDR-1	thigh	55.6	-5.7	-3.7	-3.0	-
	shin	35.9	-3.6	-2.7	-1.7	-
	shoulder	29.5	-1.5	-0.1	+0.1	-
OBE-1	thigh	55.4	-3.9	-3.3	-2.2	-
	shin	36.6	-3.5	-1.8	-1.4	-
	shoulder	29.2	-2.3	-0.2	0	-
CDR-2	thigh	52.1	-1.9	-0.9	+0.1	+0.6
	shin	38.0	-2.3	-2.0	-1.0	-0.4
	shoulder	27.6	-0.6	0	+0.1	+0.2
OBE-2	thigh	49.5	-1.5	-1.3	-0.5	-0.5
	shin	34.2	-2.2	-1.8	-0.4	+0.2
	shoulder	26.5	-0.3	0	+0.3	+0.2

Such shifts indicate a certain discoordination of the cardiovascular system, change in its reactivity and transition to another level of functioning with more stress, irrational for ground conditions. /21

In the members of the second crew, changes were less pronounced and they were observed mainly in the CDR-2. In distinction from the members of the first crew, vascular tonus was decreased in the CDR-2 and OBE-2.

Normalization of the cardiovascular system conditions occurred spasmodically. Most of the indices reached preflight values by the 3rd-6th days, but arterial pressure was elevated in the CDR-1 and CDR-2 for 14 days, and the CDR-1 even on the 36th day. Apparently, the changes in regulation of vascular tonus in the CDR-1 caused by asthenia and neurotic stratification, were fairly deep.

The results of studies with different types of load which cause an increase in requirements for the cardiorespiratory system are even more indicative.

Physical Work Capability /27

On the third day postflight, the first crew underwent a physical load on the bicycle ergometer in a recumbent position. Power was 600 kgm/min at 60±5 rev/min, duration 7 min. Both cosmonuats

TABLE 5. THE DYNAMICS OF FREQUENCY OF CARDIAC CONTRACTIONS AND ARTERIAL PRESSURE AT REST AFTER FLIGHT.

INDICES	POSITION	CREW MEMBER	PREFLIGHT	DAYS AFTER FLIGHT				
				5 HR.	I	2	3	6	I4
FREQUENCY OF CARDIAC CONTRACTIONS beats/min.	LYING	CDR -I	56-60	72	72	72	56	60	60
		OBE -I	48-50	II6	72	60	52	60	50
		CDR -2	70-72	I00	84	80	76	80	72
		OBE -2	60-62	I00	96	68	64	72	68
	SITTING	CDR -I	60-64	80	80	72	64	64	60
		OBE -I	56-60	I20	-	76	76	60	64
		CDR -2	78-80	-	96	84	84	84	80
		OBE -2	62-64	-	I08	80	72	96	72
	STANDING	CDR -I	62-64	I04	88	88	64	72	-
		OBE -I	68-76	-	-	I04	76	I00	-
		CDR -2	80-84	-	I08	I00	92	II2	88
		OBE -2	66-70	-	I24	92	80	I00	80
ARTERIAL mm mercury column	LYING	CDR -I	I20/80	I30/I05	I20/80	I30/ 70	I20/ 80	I20/ 80	-
		OBE -I	II5/70	II0/90	I20/80	II8/ 70	I20/ 70	II0/ 70	-
		CDR -2	I05/70	II5/85	I20/75	I05/ 70	I05/ 70	II5/ 70	II5/70
		OBE -2	II5/75	II5/90	I20/80	I20/ 80	II5/ 80	II5/ 75	II0/80
	SITTING	CDR -I	I20/80	I30/I20	II5/72	I40/ I20	I20/ 88	I20/ 84	I20/70
		OBE -I	II5/70	I00/85	-	II8/ 90	I04/ 76	I08/ 84	II0/75
		CDR -2	I05/80	-	II5/85	I00/ 70	I05/ 70	II5/ 70	I20/70
		OBE -2	II0/80	-	II0/80	II0/ 80	I20/ 80	II0/ 80	II0/80
	STANDING	CDR -I	II5/80	I20/I00	I30/90	I40/ 90	I28/ 96	I30/ 80	-
		OBE -I	II0/80	-	-	II0/ 90	II0/ 80	I04/ 80	-
		CDR -2	I05/80	-	I20/90	I00/ 80	I05/ 80	II0/ 80	II0/80
		OBE -2	II0/80	-	I05/90	II0/ 85	I05/ 80	I00/ 75	II0/80

TABLE 6. DYNAMICS OF BASIC INDICES OF THE BLOOD CIRCULATION SYSTEM OF THE MEMBERS OF THE FIRST CREW IN CONDITIONS OF OPERATIVE REST IN A RECUMBENT POSITION.

INDICES	CDR-1							OBE-1						
	PRE-FLIGHT	DAYS AFTER FLIGHT						PRE-FLIGHT	DAYS AFTER FLIGHT					
		I	3	5	7	I4	36		I	3	5	7	I4	36
FCC	60	59	56	58	66	63	62	49	75	55	60	53	54	43
PE	270	240	280	280	270	260	280	290	230	260	260	275	290	280
AP_{lmb}	I35	I35	I40	I45	I45	I45	I45	I25	I27	I35	I30	I30	I30	I30
AP_{bs}	II0	I25	I25	I25	I30	I20	I20	II0	II2	I25	I05	I20	I05	II5
AP_M	85	I00	I05	90	I00	I00	98	85	95	I00	80	90	85	95
AP_d	70	75	75	75	80	85	80	75	70	80	75	75	63	75
V_m	9.3	II,8	9.3	9.3	9.3	I0.8	9.3	6.7	8.8	7.I	7,I	7.I	8,I	7,6
V_e	5.6	9.0	6.3	7.5	6.9	7.5	7.5	5.6	6:4	6,0	6.0	6.0	6,4	6.0
SI	5I	34	53	50	55	32	4I	46	4I	49	34	52	49	45
SyI	3,I	2.0	2.9	2.9	3.6	2.0	2.5	2.3	3;I	2.7	2.0	2.75	2,7	I,9
SPR	27	50	36	3I	28	50	39	37	3I	37	40	32	3I	50

TABLE 7. DYNAMICS OF THE INDICES OF SYSTEMMIC BLOOD CIRCULATION IN MEMBERS OF THE SECOND CREW IN CONDITIONS OF OPERATUVE REST AND A LYING POSITION

INDICES	CDR-2					OBE-2				
	PREFLIGHT	DAYS AFTER FLIGHT				PREFLIGHT	DAYS AFTER FLIGHT			
		I	3	6	I4		I	3	6	I4
FCC	77	79	86	99	86	59	88	77	79	65
PE	260	240	250	240	250	260	230	240	230	260
AP	I30	I30	I25	I28	I45	I30	I25	I30	I30	I20
AP	II0	II0	II5	II0	I20	I20	II5	II0	II0	II0
AP	95	I00	95	90	I05	I00	I00	I00	I00	95
AP_m	75	85	85	75	85	80	85	85	85	75
V_m	9.3	8.6	8.0	9.3	9.3	9,5	9.5	9.5	7.6	9,5
V_e	7.3	6.3	6.3	6.3	7.3	7,5	6.4	7.5	6,0	7,5
SI	37	27	36	42	42	37	33	28	27	34
SvI	2.8	2.2	3.I	3.9	3.6	2.2	2.9	2.I	2,2	2.2
SPR	34	45	3I	23	29	45	34	48	45	43

successfully completed the test, however, with considerably more stress and less efficiency than before the flight: there were higher indices of cardiac contraction frequency, arterial pressure, minute volume of breathing, but then the "oxygen pulse" (OP), on the other hand, was decreased especially in the OBE-1; differing from the commander, the demand for oxygen (VO_2) was decreased during work (see Table 8). In the recovery period, the frequency of cardiac contractions and breathing was also higher but on the other hand the oxygen pulse decreased even more. On the EKG for both cosmonauts, there is a noticeable decrease in the T wave in comparison with the preflight data; for the OBE-1, a pronounced decrease in the size of the T wave in comparison with initial data before the beginning of the study is true. Recovery of pulse and amplitude indices of the EKG was slowed down. /27

A similar decrease in transferability of physical loads was observed in the second crew (Table 9). As an example, let us also introduce the results of a functional test with a 4-minute run on the KTF at a rate of 160 steps per minute which was carried out on the 4th day postflight (Table 10).

As is apparent from the Table, during such a test load, higher FCC were observed, lower sizes of stroke and minute volumes of the blood and delayed recovery of indices after load.

Recovery of physical work capability occurred gradually. On day 6, the level of physical work capability remained practically the same as on day 3. The preflight level was achieved only after 30 days.

Before the flight and for the ten days after flight, the cosmonauts of the first crew were examined for physical work capability using an echocardiograph at the All-Union Cardiological Scientific Center (Table 11). /35

Before flight, there was noted in the CDR-1: average expansion of the cavities of the left ventricle and operative hypertrophy of the myocardium, under load--a decrease in the volumes of the left ventricle (sympathetic stimulation), for a 10-minute recovery--a hypercompensatory phase.

For the OBE-1 preflight, no peculiarities were noted in the myocardium and heart cavity--an increase in the volume of the left ventricle, at 10 minutes--full recovery.

After flight, in both cosmonauts, a decrease in diastolic volume of the left ventricle was observed and an increase in thickness of the wall and mass of the left ventricle. In the OBE-1, also, an increase in the limb-systolic volume, a decrease in stroke ejection and fraction of ejection (systolic and

TABLE 8. CHANGE IN INDICES OF THE CARDIORESPIRATORY SYSTEM DURING STUDIES WITH PHYSICAL LOAD ON THE BICYCLE ERGOMETER (CDR-1 (VOLYNOV, B.V.)).

INDICES	BACK-GROUND	LOAD							RECOVERY			
		1'	2'	3'	4'	5'	6'	7'	2'	4'	6'	10'
1	2	3	4	5	6	7	8	9	10	11	12	13
FCC	56 60	83 85	90 98	88 102	98 103	92 108	90 108	93 110	66 82	59 78	60 69	57 70
RR	14 13	14 10	11 12	14 10	12 13	12 12	12 13	14 14	11 12	10 13	11 14	12 13
MOD	9.9 8.9	17.1 19.0	23.4 21.4	25.4 25.8	26.7 29.7	27.1 28.1	26.7 29.3	28.9 30.7	19.1 18.6	9.8 11.6	10.7 10.5	9.8 10.4
VO_2	310 312	496 722	1076 1049	1092 1367	1335 1544	1355 1377	1308 1465	1445 1474	726 707	314 360	353 336	323 385
VCO_2	267 258	410 663	983 963	1270 1316	1335 1544	1382 1423	1362 1494	1446 1504	802 781	363 383	332 315	275 322
QP	5.5 5.2	6.0 8.5	12.0 10.7	12.4 13.4	13.6 14.5	14.7 12.7	14.5 13.5	15.5 13.4	11.0 8.6	5.3 4.6	5.9 4.8	5.7 5.5
AP_{lmb}	155 155								155 160	145 160	145 150	135 140
AP_m	75 80								75 80	70 80	70 75	70 75
V_e	750 645								900 565	1113 565	1113 645	900 645

I	2	3	4	5	6	7	8	9	I0	II	I2	I3
SI	57,0 42,0								39.0 65.0	29.0 80.0	30.0 5I.0	37.0 50.0
SyI	3.2 2,4								2,6 4.9	I,8 6.0	I,8 3.6	2.I 3,4
ΣQRS	58.0 59.0	56.0 59,0	54,0 59,0	55.0 62.0	55,0 6I.0	56;0 63,0	55.0 6I.0	54,0 60,0	55,0 60.0	54,0 6I,0	54.0 58.0	55,0 56.0
Σ T	I8.0 I2.0	I7,0 I2.0	2I,0 I4,0	22.0 I7,0	I9,0 I5,0	22.0 I4.0	I9,0 I7,0	20.0 I8,0	I8.0 I7.0	I8.0 I4.0	I8.0 I5.0	I7.0 I4,0
					QBE-1 (ZHOLOBOV, V.M.):							
FCC	47 59	90 98	90 I08	9I II3	96 II8	96 II9	96 I22	94 I22	55 90	53 8I	50 78	52 68
PE	280 260								240 220	280 -	290 -	300 -
RR	II I6	I9 I7	20 I8	I9 I9	I8 I9	I9 I8	I8 I8	I7 I9	9 I2	9 9	9 I0	I3 I3
MOD	9.5 9.5	II.I I7.5	2I.4 22.6	25.8 27.2	26,0 29,5	26.I 27.2	28,0 28.8	28,6 30,I	I4.6 I5.3	I0.4 I0.5	8,9 8.2	7.8 7.2
VO_2	307 304	344 560	984 949	I342 II97	I326 I239	I306 II42	I372 I2I0	I373 I234	526 459	28I 305	240 262	273 252
VCO_2	266 247	355 525	899 859	I2I3 II70	I274 I298	I305 II97	I372 I267	I40I I294	467 536	3I2 326	23I 246	257 223
OP	6.7 5.7	3.8 5,7	I0:9 8.7	I4.7 I0.5	I3.8 I0.5	I3,6 9,6	I4.3 9.9	I4,6 I0.I	9.6 5.I	5.3 3.7	4.8 3,3	5,3 3,7

	1	2	3	4	5	6	7	8	9	10	11	12	13
$\overline{\Delta P_{1mt}}$		130 140								150 145	140 -	135 -	130 -
$\overline{\Delta P_m}$		70 80								70 75	70 -	70 -	70 -
$\overline{V_e}$		645 565								750 565	645 -	645 -	645 -
SI		42.0 53.0								410.0 55.0	- - - -	- - - -	- - - -
$Sv\bar{I}$		1.9 3.1								2.5 3.8	3.0 - -	2.5 - -	2.3 - -
ΣQRS		77.0 73.0	82.0 79.0	80.0 83.0	70.0 78.0	74.0 80.0	71.0 78.0	73.0 78.0	74.0 77.0	70.0 77.0	63.0 73.0	77.0 76.0	78.0 69.0
ΣT		28.0 14.0	22.0 3.0	18.0 7.0	17.0 8.0	17.0 7.0	22.0 8.0	18.0 6.0	17.0 7.0	22.0 8.0	20.0 6.0	23.0 8.0	25.0 10.0

NOTATION: UPPER LINE = PREFLIGHT 7/2/1976.
LOWER LINE = POSTFLIGHT 8/27/1976.

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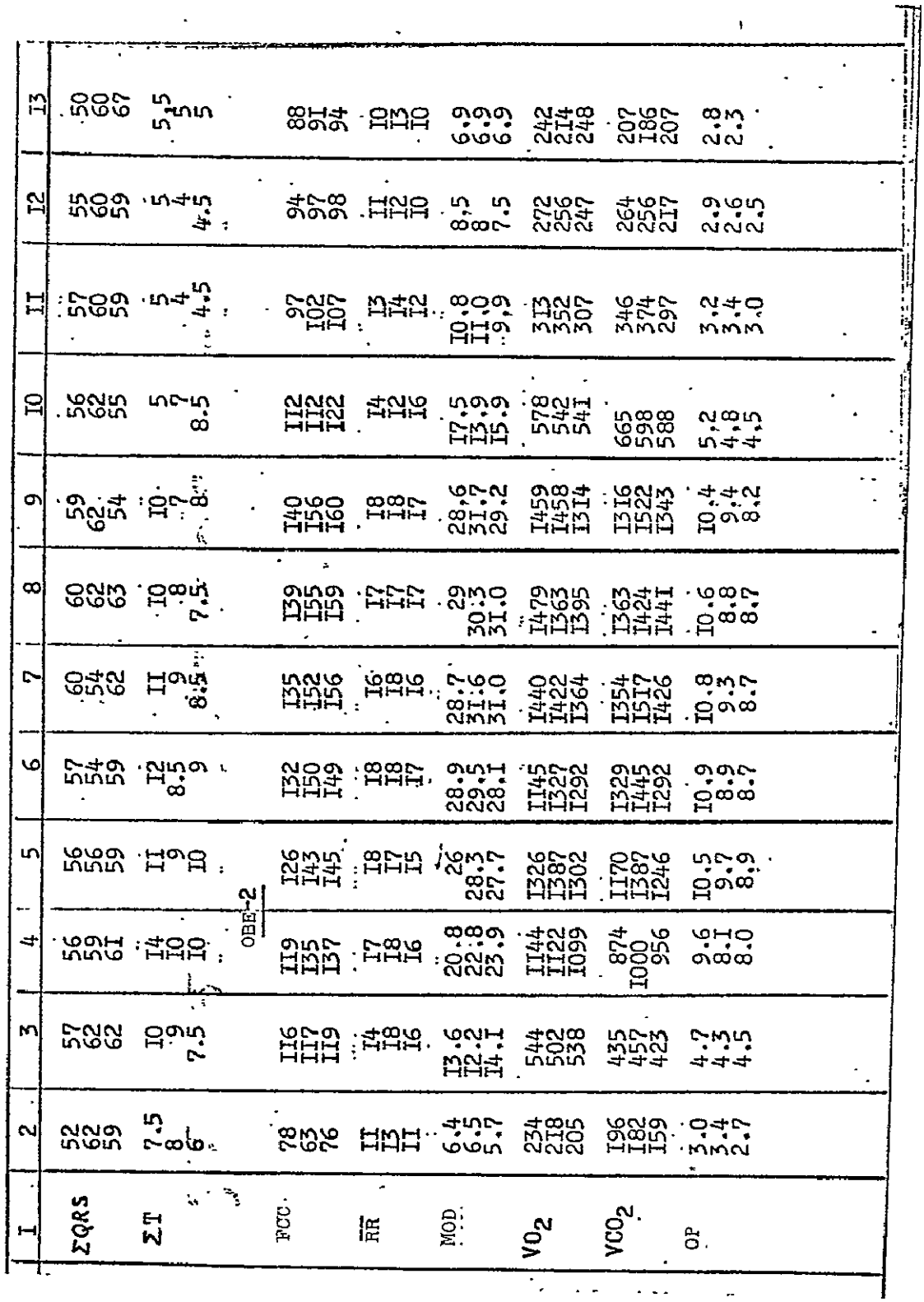
TABLE 9. CHANGE IN INDICES OF THE CARDIORESPIRATORY SYSTEM DURING STUDIES WITH PHYSICAL LOAD ON A BICYCLE-ERGOMETER.

INDICES	BACK-GROUND	LOAD							RECOVERY			
		1′	2′	3′	4′	5′	6′	7′	2′	4′	6′	10′
I	2	3	4	5	6	7	8	9	10	11	12	13
			ICDR-2									
FCC	78	115	124	128	130	137	136	136	95	92	87	87
	72	121	133	143	147	147	146	149	111	104	100	98
	84	118	133	140	143	142	145	142	107	101	101	100
RR	15	14	15	17	16	17	18	17	8	6	10	10
	10	15	17	19	19	16	15	17	9	13	12	9
	6	14	15	16	16	16	17	20	13	7	9	11
MOD	8.22	16.7	24.5	26.7	28.5	30.8	31.3	30.6	13.0	9.2	8.4	8.2
	7.6	15.8	25.1	33.2	33.2	34.4	36.9	36.2	17.0	12.7	9.2	9.6
	6.3	16.3	21.8	29.9	32.3	30.8	31.4	35.1	17.0	10.3	9.35	7.8
VO_2	279	651	1299	1335	1368	1448	1471	1408	494	322	286	262
	264	521	1104	1494	1361	1376	1476	1448	595	317	285	297
	264	636	1068	1435	1486	1413	1474	561	319	319	308	265
VCO_2	221	518	980	1121	1226	1294	1346	1255	507	331	277	221
	196	426	904	1361	1394	1410	1550	1448	680	374	271	278
	227	522	959	1375	1486	1386	1413	1509	612	339	290	242
QP	3.6	5.7	10.5	10.4	10.5	10.5	10.8	10.3	5.2	3.5	3.3	3.0
	3.9	4.3	8.3	10.4	9.3	9.4	10.1	9.7	5.3	3.1	2.8	3.0
	3.6	5.2	8.0	10.0	10.1	9.4	9.7	9.9	5.0	3.0	3.0	2.7
AP_{cs}	120								150	140	135	125
	135								145	140	140	130
	130								-	-	140	130
AP_d	75								70	70	70	75
	80								80	75	80	80
	88								-	-	85	85



	1	2	3	4	5	6	7	8	9	10	11	12	13
	ΣQRS	52 62 59	57 62 62	56 59 61	56 56 59	57 54 59	60 54 62	60 62 63	59 62 54	56 62 55	57 60 59	55 60 59	50 60 67
	ΣT	7.5 8 6	I0 9 7.5	I4 I0 I0	II 9 I0	I2 8.5 9	II 9 8.5	I0 8 7.5	I0 7 8	5 7 8.5	5 4 4.5	5 4 4.5	5.5 5 5
OBE-2	FCC	78 63 76	II6 II7 II9	II9 I35 I37	I26 I43 I45	I32 I50 I49	I35 I52 I56	I39 I55 I59	I40 I56 I60	II2 II2 I22	97 I02 I07	94 97 98	88 9I 94
	$\overline{RR}$	II I3 II	I4 I8 I6	I7 I8 I6	I8 I7 I5	I8 I8 I7	I6 I8 I6	I7 I7 I7	I8 I8 I7	I4 I2 I6	I3 I4 I2	II I2 I0	I0 I3 I0
	MOD	6.4 6.5 5.7	I3.6 I2.2 I4.I	20.8 22.8 23.9	26 28.3 27.7	28.9 29.5 28.I	28.7 3I.6 3I.0	29 30.3 3I.0	28.6 3I.7 29.2	I7.5 I3.9 I5.9	I0.8 II.0 9.9	8.5 8 7.5	6.9 6.9 6.9
	VO_2	234 2I8 205	544 502 538	II44 II22 I099	I326 I387 I302	II45 I327 I292	I440 I422 I364	I479 I363 I395	I459 I458 I3I4	578 542 54I	3I3 352 307	272 256 247	242 2I4 248
	VCO_2	I96 I82 I59	435 457 423	874 I000 956	II70 I387 I246	I329 I445 I292	I354 I5I7 I426	I363 I424 I44I	I3I6 I522 I343	665 598 588	346 374 297	264 256 2I7	207 I86 207
	OP	3.0 3.4 2.7	4.7 4.3 4.5	9.6 8.I 8.0	I0.5 9.7 8.9	I0.9 8.9 8.7	I0.8 9.3 8.7	I0.6 8.8 8.7	I0.4 9.4 8.2	5.2 4.8 4.5	3.2 3.4 3.0	2.9 2.6 2.5	2.8 2.3

I	2	3	4	5	6	7	8	9	I0	II	I2	I3
AP_{lmb}	I35								I55	I50	I35	I35
	I35								I55	I40	I30	I35
	I25								I60	I40	I30	I25
AP_d	75								80	80	80	75
	90								95	90	80	90
	90								80	80	85	85
V_e	-								-	-	-	-
	7.5								5.6	7,5	5.6	7.5
	6.4								6.4	6.4	6,4	6.4
ST	-								-	-	-	-
	33								30	25	47	33
	28								32	38	34	32
Sy/I	-								-	-	-	-
	2.3								3.2	2.5	4.3	3.0
	2.3								3.6	3.8	3.3	2.8
ΣQRS	58	48	50	5I	56	52	54	55	57	57	57	57
	54	47	53	47	50	50	53	47	54	54	56	54
	52	52	47	53	53	52	52	65	53	53	52	52
ΣT	20	I5	I8	I7	I9	I6	I8	I5	I3	I5	I6	20
	26	I4	I8	I7	I9	20	I8	I7	I9	I5	I6	20
	20	9	I3	I5	II	I2	I2	I3	I6	II	I2	I6

NOTATION: FIRST LINE = PREFLIGHT INDICES, SECOND = DAY 3 POSTFLIGHT, THIRD = DAY 6 POSTFLIGHT.

TABLE 10. DYNAMICS OF FCC, STROKE AND MINUTE VOLUMES OF BLOOD DURING A FUNCTIONAL TEST ON

	BACKGROUND			RUN				RECOVERY							
	-2'	-I'	-30"	I'	2'	3'	4'	I0"	20"	30"	I'	I,5'	2'	3'	4'
				CDR-2											
FCC	83 I00	84 I07	86 I0I	II4 I50	I23 I53	I26 I56	I20 I50	II0 I45	II3 I43	I00 I30	93 I24	92 III	98 II5	I0I I09	I0I I04
SV	60 36	58 37	60.5 34	-	-	-	-	67 35	60 38	64,6 29	46.6 29	49,5 32	45.6 3I	46.4 33	5I.8 3I
MV	5.0I 3.66	4.9 3.98	5.2 3.4I	-	-	-	-	7.38 5.I7	6.74 5.46	6.47 3.8I	4.35 3.6	4.57 3.58	4.47 3.54	4.7 3.6	5.23 3.I8
				OBE-2											
FCC	7I 78	60 79	65 83	I26 I47	I38 I59	I38 I62	I35 I50	I5I I63	- I56	I28 I5I	94 I25	- II7	63 II8	68 III	7I I05
SV	59 29	62 32	63 26	-	-	-	-	49 35	- 430	46.4 30	42 20	- 22	60.6 I7	50 20	49 I7
MV	4.I2 2.29	3.75 2.56	4.09 2.I9	-	-	-	-	7.38 5.69	- 4.6I	6.08 4.5I	3.95 2.53	- 2.58	3.83 I.99	3.39 2.23	3.48 I.77

UPPER LINE -- PREFLIGHT; LOWER -- POSTFLIGHT.

TABLE 11. RESULTS OF ECHOCARDIOGRAPHIC EXAMINATION WITH MEASURED PHYSICAL LOAD.

	INITIAL STATE	LOAD			RECOVERY	
		300X·3'	600X·3'	900X·3'	5 MIN.	IO MIN.
			CDR-I			
FCC	57 65	75 88	90 96	I03 II6	65 80	60 76
AP	I35/80 I30/80	I60/85 I50/80	200/75 I80/80	220/95 220/80	I40/75 I45/78	I30/80 I35/80
SV	I25 I06	II6 86	I03 83	98 83	92 94	94 I09
FRACTION OF EJECTION	67 72	75 69	79 70	83 70	5I 70	59 74
MV	7.I25 6.89	8.7 7.568	9.27 7.968	I0.09 9.628	5.98 7,52	5.64 8.284
OPCC	II03 II2I	I0I0 I09I	I006 II37	I082 I05I	I292 I066	I370 949
			OBE-I			
FCC	56 60	75 92	I00 II2	II5 I50	73 84	60 76
AP	I30/80 II5/70	I45/75 I30/70	I80/50 I60/75	200/40 I90/80	I35/80 II8/75	I35/80 II8/75
SV	II9 85	I27 97	I32 92	I38 II4	99 I30	II5 I23
FRACTION OF EJECTION	69 58	63 54	68 38,5	80 45	57 62	59 74
MV	6.664 5.I	9:525 8.924	I3.2 I0.304	I5.87 I7.I	7.227 I0,92	6.9 9.348
OPCC	II60 I332	825 806	565 80I	470 545	I087 654	II39 764

NOTATION: UPPER LINE - PREFLIGHT, LOWER LINE - POSTFLIGHT.

diastolic dilations of the left ventricle, decrease in contractile capability of the myocardium) were observed. Moreover, an increase in the left auricle, a decrease in amplitude and rate of motion of the mitral valve were observed. According to the results of echocardiographic studies, one can conclude that as a result of space flight, the cosmonauts developed diffusive changes in the myocardium, a decrease in tonus of the cardiac muscle and contractile capability of the myocardium.

Echocardiographic studies were not carried out on the second crew.

Evaluating the physical work capability of the crews as a whole, one can say that that of the CDR-1 decreased less than in the crew which made a 63-day flight; in the OBE-1, it was approximately to the same degree as in this crew. The decrease in physical work capability of the members of the second crew did not differ from manifestations observed after preceding flights of similar duration and complexity.

Postural Loads /37

As usual, after flight, the orthostatic stability of all the cosmonauts was decreased. It was a particularly pronounced decrease of orthostatic stability in members of the first crew.

After 15 hours after landing (immediately after the first night's sleep) the CDR-1 with great difficulty completed the active orthostatic test (standing in a position of "attention" for a period of five minutes). For the OBE-1, the test was stopped after one minute because of development of a pre-collapse state.

On the second day, a passive orthostatic test was conducted on a rotating table. For the OBE-1, it was stopped after 5 minutes due to the development a pre-collapse state (pallor, weakness, reduction of pulse, cold sweats). The results of studies of systemic blood circulation during the passive orthostatic tests are presented in Tables 12 and 13. Here the IIOS--the integral index of orthostatic stability, is given in conventional units: 100-86--outstanding stability, 85-71--good, 70-56--satisfactory, 55-41--decreased, 40 and less--poor.

The dynamics of recovery of orthostatic stability according to this integral index are presented in Figures 3 and 4.

Recovery of OS, like resistance to other load effects, occurred spasmodically. Then in the OBE-2 and particularly in the OBE-1, it recovered slowly. In the OBE-1, even at 36 days, the OS was noticeably decreased. The basic mechanism of poor transferability of the postural effect in him was disorder

TABLE 12. DYNAMICS OF MEAN VALUES OF BASIC INDICES OF SYSTEMMIC BLOOD CIRCULATION DURING A PASSIVE ORTHOSTATIC TEST.

	CDR-I						OBE-I					
	PREFLIGHT	DAYS POSTFLIGHT					PREFLIGHT	DAYS POSTFLIGHT				
		2	5	7	I4	36		2*	5	7	I4	36
FCC	64	7I	7I	77	69	68	75	87	II5	III	99	95
PE	220	220	220	202	220	23I	208	I60	I72	I90	I89	I84
AP_{lmb}	I32	I40	I46	I40	I30	I44	II4	II0	II0	II3	II6	I08
AP_m	95	I06	I04	II0	99	I03	90	85	92	9I	9I	9I
AP_d	75	75	83	85	86	8I	75	70	77	73	70	74
VM	9.3	I0.2	I0.8	9.7	I0.8	I0.3	7.8	9.5	8.7	7.0	9.8	9.2
V_e	8.4	7.4	7.0	8.I	9.9	8.5	7.5	5.6	6.6	6.4	6.9	6.I
SI	24	38	36	27	I9	32	23	2I	I8	27	29	I7
SyI	I.5	2.7	2.5	2.I	I.3	2.2	I.74	2.7	2.I	3.0	2.9	I.6
SPR	64	40	43	52	79	47	56	3I	46	3I	34	54
IIOS	96	83	90	9I	90	97	77	I9	6I	6I	68	66

NOTATION: *SECOND VALUES OF INDICES PRESENTED FOR 5-MINUTE OP BEFORE TURNING IN A HORIZONTAL POSITION.

TABLE 13: DYNAMICS OF MEAN VALUES OF BASIC INDICES OF SYSTEMMIC BLOOD CIRCULATION DURING A PASSIVE ORTHOSTATIC TEST

INDICES	CDR-2					OBE-2				
	PREFLIGHT	DAYS POSTFLIGHT				PREFLIGHT	DAYS POSTFLIGHT			
		I	3	6	I4		I	3	6	I4
FCC	97	II8	I03	II7	99	72	II9	98	I05	8I
PE	I90	I62	I96	I70	I78	205	I68	I88	I78	200
AP_{Amb}	I3I	I25	I25	I2I	I40	I29	I20	II5	II2	II5
AP_m	I0I	I04	I00	92	II0	99	98	94	99	95
AP_d	8I	89	83	79	83	79	85	8I	83	76
VM	930	946	800	930	930	I0I0	8I0	950	8I0	880
V_e	730	790	7I0	8I0	760	880	750	790	680	780
SI	22	I3	29	I7	25	25	I7	I8	I7	2I
SyI	2.I4	I.58	3.0	2.0	2.5	I.8	2.0	I.8	I.8	I.7
SPR	47	66	33	46	46	58	49	53	55	56
IIOS	79	6I	77	64	77	93	63	70	63	78

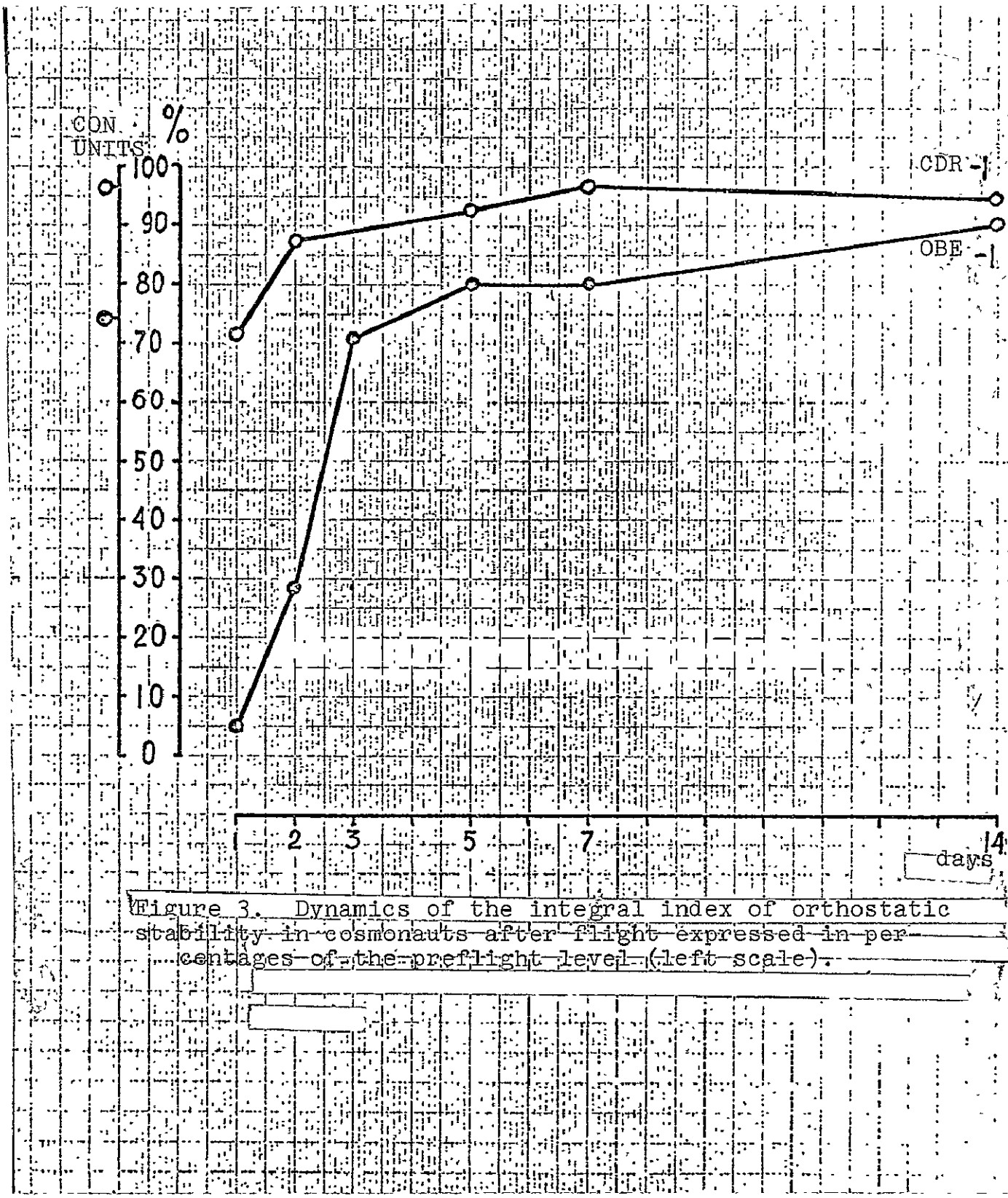


Figure 3. Dynamics of the integral index of orthostatic stability in cosmonauts after flight expressed in percentages of the preflight level (left scale).

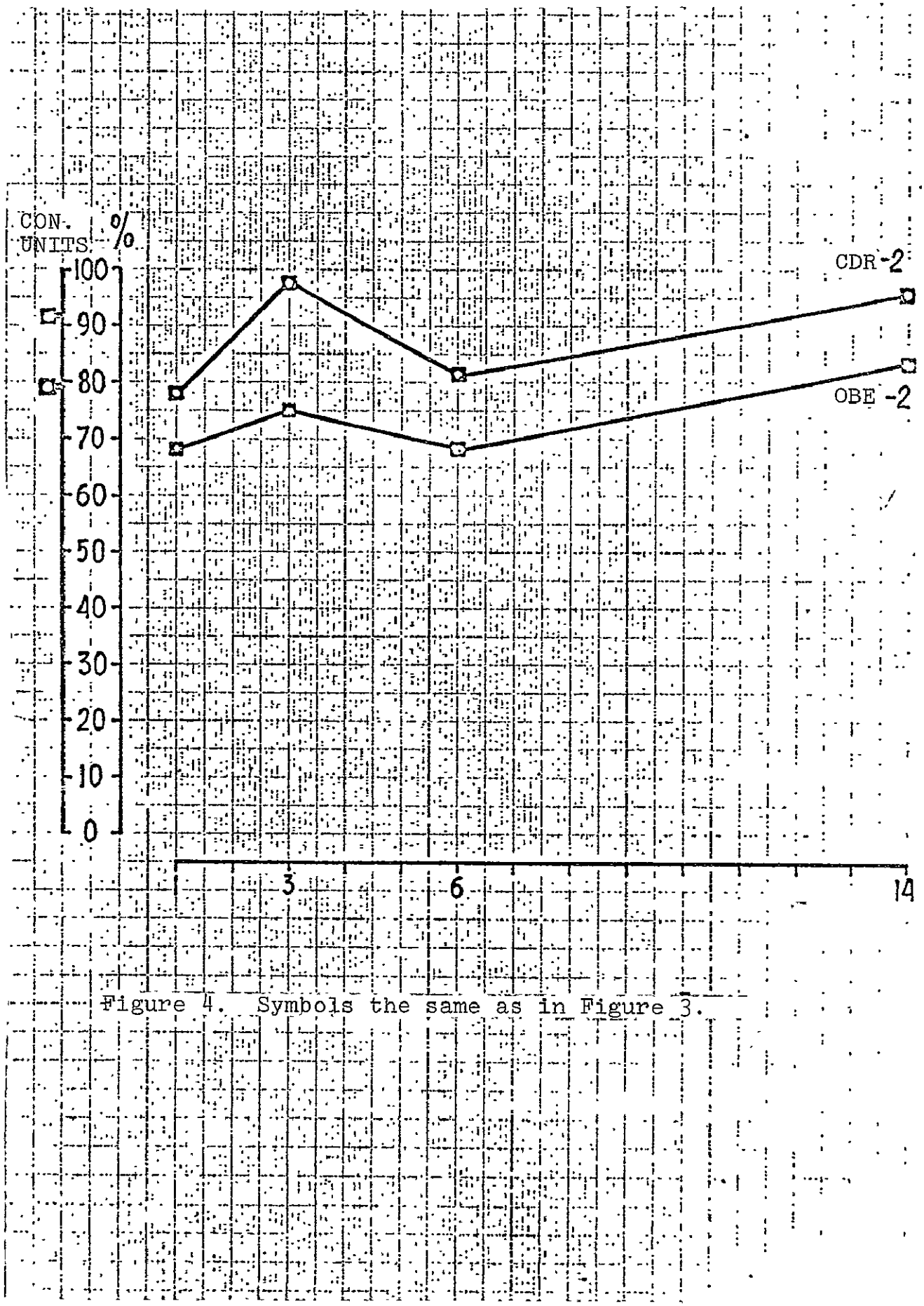


Figure 4. Symbols the same as in Figure 3.

of regulation of tonus of the arterial blood vessels and the vessels of the head. Apparently, changes occurring in flight in regulation of vascular tonus had been fairly stable in him.

Antiorthostatic Tests

The postural test lying in a position with the head below the feet is conducted in order to study restructuring of regulation of the vascular tonus of the head after flight for /42
compensation of the redistribution of the blood in the upper half of the body. As is well known, in weightlessness one observes overfilling of the vessels of the chest, neck and head with blood; then, in the opinion of the cosmonauts, the feeling of fullness of the head with blood gradually decreases. It would be interesting to find out whether or not this only involves getting used to, that is, whether or not it is a purely subjective sensation or does the vascular tonus of the upper half of the body change decreasing the flow of blood in this area of the vascular channel.

In preceding flights, it was pointed out that the tonus of vessels of the head increases. This made it possible to develop a special system of preflight training in order to "prepare" the vessels of the upper half of the body before the flight for the expected change in pressure. The indicated training is still optional, that is, an optimum regime has not yet been found.

The first crew trained very little (5--8 training periods) and the effect of training was very pronounced on the CDR-1 whose initial stability in an antiorthostatic position was lower than that of the OBE-1.

After the flight, many of the indices of the blood circulation system in an antiorthostatic position (AOP) became close to the indices in a horizontal position (HP), in particular, the stroke index, the mean lateral arterial pressure; besides this, the tonus of the vessels increased (Table 14). Then, these shifts are more pronounced in the OBE-1 in whom stability to AOP was higher in the preflight period than it was in the CDR-1. Such dynamics attest to restructuring of regulation of the blood circulation system directed at compensation of redistribution of blood to the head.

At the same time that the systemic hemodynamics gradually recover and after two weeks, it practically returns to the preflight level, reactions to AOP on day 5 was increased in comparison with day 1. Even on day 36, it was still pronounced. This attests to the fact that changes in regulation of blood /44
circulation of the head after flight are more stable than changes in the systemic hemodynamics. Possibly, such stable changes of

TABLE 14. CHANGE IN INDICES OF BLOOD CIRCULATION IN A HORIZONTAL POSITION IN A POSTURE TEST AND REACTIONS TO AOP -30°.

	HORIZONTAL POSITION				AOP/HP x 100			
	PREFLIGHT		CHANGE AFTER FLIGHT IN % OF PREFLIGHT VALUE		PREFLIGHT		DIFFERENCE BETWEEN POST-FLIGHT AND PREFLIGHT RATIOS OF THE INDICES	
	CDR-I	OBE-I	CDR-I	OBE-I	CDR-I	OBE-I	CDR-I	OBE-I
FCC	60	49	-7	+12	87	92	+11	+12
PE	270	290	+3	-11	111	107	-11	-4
AP_{lmb}	135	125	+3	+8	95	96	+7	-1
AP_d	70	75	+7	+6	100	97	-11	-3
AP_m	85	92	+1	+1	118	120	-10	-12
V_m	9.3	6.7	0	+5	87	106	+15	-2
V_e	5.6	5.6	+23	+7	91	100	+18	+5
SI	51	46	+4	+7	124	115	-16	-15
SPR	27	37	+33	0	96	100	-13	-14

hemodynamics of the head involve not only functional but also morphological restructuring of the vessels.

In members of the second crew, stability toward AOP after flight changed insignificantly (Table 15).

/45

TABLE 15. CHANGE IN INDICES OF BLOOD CIRCULATION IN AN ANTI-ORTHOSTATIC POSITION OF A POSTURE TEST AND RELATIVE REACTION TO AOP ON DAY 1 POSTFLIGHT

$\frac{AOP}{}-30^0$ $\frac{AOP}{HP}\times 100$

	PREFLIGHT		CHANGE AFTER FLIGHT IN % OF PREFLIGHT VALUE		PREFLIGHT		DIFFERENCE BETWEEN POST AND PREFLIGHT RATIO	
	CDR-2	OBE-2	CDR-2	OBE-2	CDR-2	OBE-2	CDR-2	OBE-2
FCC	76	59	+24	+34	99	100	+20	-10
PE	275	280	-9	-14	106	107	-2	-3
AP_{lmb}	133	132	-5	-3	102	102	-4	0
AP_d	78	78	+6	+3	104	98	-6	-4
AP_m	110	105	0	0	116	124	-2	-4
V_m	8.4	8.6	-5	-6	90	91	+3	-6
V_e	6.6	6.8	-5	-18	90	91	+10	-4
SI	39	49	-13	-16	106	132	+20	-8
SyI	3.0	2.9	+7	+14	107	132	+38	-18
SPR	32	32	-3	-3	94	71	-25	+21

In truth, they had a significantly shorter time period for flight and also a larger quantity of preflight training (24 for each cosmonaut). /44

This question requires further study, that is, one has not yet found the precise relationship between stability to AOP and clearness of the sense of fullness of blood in the head including such undesirable manifestations as headaches. At the same time, most of the cosmonauts report positively on training sessions for AOP and in the first days after flight preferred to sleep without pillows. During tests with AOP, they clearly indicate the angle of slope of the table at which the feeling of fullness in the head is comparable with the flight. From day to day this angle decreases in some earlier and in some later but usually after 5--7 days it is at zero.

Rheoencehpalography

The dynamics of blood circulation in the head and also the condition of vessel tonus of the brain were traced using a REG.

In the CDR-1, postflight, the REG showed hypertension reactions. In the OBE-1, in whom the tonus of the vessels of the head in flight was singularly changed (see above), in the first days postflight, asymmetry of hyperemia and vascular tonus of the cerebrum hemisphere were observed on a background of total decrease of tonus of the head vessels. Recovery also had a sporadic character and on day 5, the changes indicated were even more pronounced than on the first day (Table 16 and 17).

LBNP /48

As was indicated above, in the opinion of the cosmonauts, the test with negative pressure on the lower part of the body in flight transfers well. The reactions of the cardiovascular system to LBNP in the CDR-1 and CDR-2 was average: the frequency of cardiac contractions increased almost as it had preflight, arterial pressure was almost unchanged, stroke volume of blood was somewhat decreased (Tables 18 and 20).

In the OBE-1, transferability of the tests with LBNP in flight, decreased noticeably from test to test. This was noticeable with a more pronounced increase of FCC, a decreased stroke (and sometimes minute) volume of blood, and by a decreased pulse pressure (Table 19). Some limitation of compensatory possibilities of the cardiovascular system on LBNP was observed in him before flight.

Somewhat more marked than on Earth, with the reaction to LBNP in the OBE-2 on day 12 of flight (Table 21): a significant increase in the pulse rate, decrease in peripheral resistance of vessels and propagation of the pulse wave along the aorta.

After flight, on the day of landing, a decrease in

TABLE 16. DYNAMICS OF RHEOENCEPHALOGRAPHIC INDICES IN CONDITIONS OF OPERATIVE REST IN A LYING POSITION

INDICES		CDR-I					OBE-I				
		PREFLIGHT	DAYS POSTFLIGHT				PREFLIGHT	DAYS POSTFLIGHT			
			I	2	5	7		I	2	5	7
A_1, MOM	l	I40	-	70	90	-	II0	I60	60	I50	I00
	r	I00	-	60	90	-	95	I20	70	60	75
C_1, MOM	l	I20	-	75	I00	-	I00	I20	50	I20	90
	r	II0	-	90	I20	-	95	90	50	40	80
PI,%	l	79	-	93	I00	-	80	63	50	60	70
	r	90	-	I42	I22	-	75	58	57	33	73
g-suit conv. unit	l	88	-	59	73	-	78	84	45	88	70
	r	78	-	63	80	-	73	68	47	4I	62

TABLE 17. DYNAMICS OF RHEOENCEPHALOGRAPHIC INDICES IN CONDITIONS OF OPERATIVE REST IN A LYING POSITION —

INDICES		CDR-2						OBE-2					
		PREFLIGHT	0	I	3	6	I4	PREFLIGHT	0	I	3	6	I4
A, MOM	l	80		II5	90	55	75	60		50	25	30	40
	r	55		65	60	70	65	60		50	75	60	60
C, MOM	l	65		II0	I05	45	65	70		50	40	40	50
	r	50		50	50	45	50	70		40	70	60	60
DI, %	l	50		65	I00	45	53	I00		75	I48	II7	I00
	r	65		70	63	40	47	I00		70	67	75	75
g-suit conv. unit	l	55		75	7I	40	53	53		40	3I	32	4I
	r	44		44	44	43	45	53		36	54	46	49

TABLE 18. RESULTS OF TESTS WITH LBNP ON THE CDR-1 (VOLYNOV, B.V.)

TIME PERIOD	INDEX	BACK-GROUND	NEGATIVE PRESSURE, MM MERCURY COLUMN					RECOVERY MIN.				
			25	25	35	35	35	I	2	3	4	5
I	2	3	4	5	6	7	8	9	I0	II	I2	I3
PREFLIGHT	FCC	54	53	53	55	55	55	53	5I	53	5I	5I
	AP MIN.	67	68	66	67	68	70	63	64	66	63	60
	MID.	86	84	82	83	83	86	84	82	82	83	86
	LAT.	II0	I04	I03	I03	I03	I0I	I06	I05	II0	I07	III
	LIMB	I30	I22	I22	I23	I22	I2I	I32	I30	I30	I28	I30
	PULS	43	36	37	36	35	3I	43	4I	44	44	5I
	SV	I02	89	9I	86	80	68	I02	97	I05	I04	I20
	MV	5.5	4.7	4.9	4.7	4.4	3.7	5.4	5.0	5.5	5.3	6.2
IN-FLIGHT DAY I4	FCC	50	54	54								
	AP MIN.	70	7I									
	MID.	96	I00									
	LAT.	I32	I22									
	LIMB	I53	I43									
	PULS	62	5I									
	SV											
	MV											
DAY 45	FCC	53	59	60	6I	63	65	66	83			
	AP MIN.	67	70	68	70	65	66	65	65			
	MID.	92	95	95	97	98	99	I06	95			
	LAT.	I2I	II5	II8	I22	I20	I20	I20	II8			
	LIMB	I47	I40	I35	I45	I46	I40	I45	I52			
	PULS	54	45	50	52	55	54	55	53			
	SV											
	MV											
POSTFLIGHT DAY 0	FCC	55	53	52	55	54	53	52	50	66	49	49
	AP MIN.	53	53	53	52	54	55	50	54	52	53	53
	MID.	8I	80	76	82	83	8I	79	80	80	78	78
	LAT.	I03	I02	98	I00	I02	I05	I05	I06	I00	I02	I0I
	LIMB	I29	I20	I2I	I3I	I20	I20	I28	I25	I24	I22	I25

1	2	3	4	5	6	7	8	9	10	11	12	13
	PULS	50	49	45	48	48	50	55	52	48	49	48
	SV	103	103	102	105	105	104	119	120	121	114	116
	MV	5.7	5.5	5,3	5.8	5.6	5.5	6;2	6.0	8.0	5.6	5.7
DAY 4	FCC	59	62	64	66	64	64	56	54	54	53	54
	AP MIN.	63	65	65	66	65	75	64	63	64	65	65
	MID.	90	94	84	89	89	96	92	88	83	92	95
	LAT.	113	112	95	100	102	114	112	118	110	121	114
	LIMB	132	128	116	125	120	122	145	138	128	130	132
	PULS	50	47	30	34	37	32	48	55	46	56	49
	SV	130	92	56	67	71	70	119	140	115	137	120
	MV	7.6	5.7	3.6	9.4	4.6	4.5	6.7	7.5	6.2	7.2	6.5
DAY 17	FCC	62	61	63	64	64	63	61	59	57	56	57
	AP MIN.	60	58	61	55	59	64	55	65	57	58	56
	MID.	93	94	92	90	95	94	90	93	98	94	94
	LAT.	115	110	110	105	105	109	112	120	118	116	115
	LIMB	142	133	130	122	132	130	146	141	150	145	142
	PULS	56	52	49	50	46	45	57	55	61	58	59
	SV	134	122	111	125	116	121	154	126	148	130	142
	MV	8.2	7.5	7.0	8.0	7.4	7.6	9.4	7.4	8.5	7.3	8.1

TABLE 19. RESULTS OF TESTS WITH LBNP ON THE OBE-1 (ŽHOLOBOV, V.M.)

TIME PERIOD	INDEX	BACK-GROUND	NEGATIVE PRESSURE, MM-MERCURY COLUMN					RECOVERY MIN.				
			25	25	35	35	35	I	2	3	4	5
I	2	3	4	5	6	7	8	9	I0	II	I2	I3
PRE-FLIGHT	FCC	43	43	47	48	48	47	46	4I	47	43	43
	AP MIN.	54	5I	56	57	54	60	53	53	52	52	53
	MID.	82	80	82	80	83	85	82	85	8I	78	82
	LAT.	99	95	98	95	96	I00	99	I0I	I0I	I03	I02
	LIMB	I22	II8	II4	II2	II8	II5	I23	I24	I27	I27	I22
	PULS	45	44	42	38	42	40	46	48	49	5I	49
	SV	I24	I0I	I03	87	9I	87	I28	I24	I3I	I33	I29
	MV	5,3	4,3	4,9	4,I	4,4	4,I	5,9	5,I	6,I	5,7	5,6
IN-FLIGHT DAY 7	FCC	4I	54	54	-	63	57					
	AP MIN.	48	47	-	-	50	-					
	MID.	42	83	-	-	78	-					
	LAT.	I00	92	-	-	95	-					
	LIMB	I32	I28	-	-	II3	-					
	PULS	52	45	-	-	45	-					
	SV	I2I	58	-	-	38	-					
	MV	5,0	3,I	-	-	2,4	-					
DAY 13	FCC	4I	47	59	68	-	68					
	AP MIN.	5I	50	53	55	60	53					
	MID.	87	84	90	98	-	98					
	LAT.	II0	I05	I05	II2	-	I03					
	LIMB	I37	I27	I23	I25	-	-					
	PULS	59	55	52	57	-	50					
	SV	I34	I04	I05	95	-	93					
	MV	5,6	4,9	6,2	6,4	-	6,3					
DAY 30	FCC	5I	65	75	86	85	8I					
	AP MIN.	50	-	49	-	49	48					
	MID.	80	-	82	-	85	87					
	LAT.	I06	-	I04	-	I0I	99					
	LIMB	I40	-	I23	-	I23	I22					
	PULS	56	-	55	-	52	5I					
	SV	I37	-	64	-	94	78					
	MV	7,0	-	4,8	-	7,9	6,3					

I	2	3	4	5	6	7	8	9	I0	II	I2	I3
DAY 44	FCC	58	73	77	95	88	-	56	55	60		
	AP MIN	57	57	56	56	57	-	63	58	60		
	MID.	79	79	79	85	87	-	85	80	78		
	LAT.	I08	I06	I05	I08	I05	-	I03	I04	I02		
	LIMB	I32	I25	I28	I25	I28	-	I32	I25	I30		
	PULS	5I	49	49	52	48	-	40	46	42		
	SV	I2I	9I	80	9I	73	-	83	89	98		
	MV	7,0	6,6	6,2	8,6	6,5	-	4,7	4,9	5,9		
POST-DAY 4	FCC	52	62	65	69	7I	68	53	50	47	50	5I
	AP MIN	62	60	66	68	66	70	66	64	65	62	60
	MID.	92	89	94	98	96	96	93	97	93	92	95
	LAT.	II2	II0	I07	I08	I06	II0	I20	II8	II5	II2	II4
	LIMB	I38	I28	I26	I2I	I25	I28	I40	I40	I42	I40	I36
	PULS	50	50	4I	40	40	40	54	54	50	50	54
	SV	I62	II8	80	7I	76	68	I54	I65	I54	I53	I7I
	MV	8,3	7,3	5,2	4,9	5,4	4,6	8,2	8,2	7,3	7,7	8,7
DAY I7	FCC	65	76	78	92	85	84	75	66	65	65	62
	AP MIN	55	57	62	62	60	62	59	56	56	54	53
	MID.	77	75	82	8I	82	84	8I	80	78	78	75
	LAT.	99	96	98	99	I00	96	I02	I03	I0I	I05	I03
	LIMB	II4	II4	II8	I28	II2	II4	I22	I30	I30	I24	I26
	PULS	44	39	36	37	40	34	43	47	45	5I	50
	SV	I03	70	65	54	7I	65	I05	I02	97	II0	I06
	MV	6,6	5,3	5,I	5,0	6,0	5,5	7,9	6,7	6,3	7,I	6,7

TABLE 20. RESULTS OF A TEST WITH LBNP ON THE CDR-2 (GORBATKO, V.V.)

TIME PERIOD	INDICES	BACK-GROUND	NEGATIVE PRESSURE-MM MERCURY-COLUMN					RECOVERY MIN				
			25	25	35	35	35	I	2	3	4	5
PRE-FLIGHT	FCC	78	94	92	97	96	92	82	75	74	75	70
	AP MIN.	69	67	69	78	79	79	68	72	69	69	66
	MID.	94	87	88	I04	95	95	97	94	90	94	99
	LAT.	I08	98	I03	II8	II3	II0	II7	II2	II0	II0	III
	LIMB	I46	I25	I32	I38	I45	I45	I50	I50	I45	I42	I42
	PULS	39	3I	34	40	34	3I	49	40	4I	4I	45
	SV	83	44	45	49	43	37	I04	86	8I	83	9I
	MV	6.5	4.2	4.2	4.7	4.I	3.4	8.5	6.5	6.0	6.2	6.4
IN-FLIGHT DAY 13	FCC	69	84	80	9I	85	82	70	67	64	-	8I
	AP MIN.	62	-	63	68	65	67	62	60	60	-	67
	MID.	93	-	96	94	95	92	92	86	90	-	92
	LAT.	I09	-	I07	I09	II0	II0	II3	II5	II0	-	I08
	LIMB	I52	-	I39	I35	I35	I35	I35	I40	I42	-	I40
	PULS	47	-	44	4I	45	43	5I	55	50	-	4I
	SV	I06	-	85	76	85	85	I02	I05	I00	-	82
	MV	7.3	-	6,8	6.9	7.2	7.0	7.I	7.0	6.4	-	6.6
POST-FLIGHT DAY 0	FCC	84	I02	96	98	I03	I0I	74	69	75	82	74
	AP MIN.	65	67	74	73	72	78	69	72	70	70	7I
	MID.	9I	92	94	90	9I	98	95	95	90	96	90
	LAT.	I06	I05	I03	I0I	I04	I06	II7	II0	II0	I09	I09
	LIMB	I44	I37	I28	I30	I33	I27	I50	I52	I46	I44	I48
	PULS	4I	38	29	28	32	28	38	38	40	39	38
	SV	86	57	40	40	44	40	76	83	90	86	79
	MV	7.2	5.8	3.9	3.9	4.6	4.0	5.6	5.8	6.7	7.0	5.8
DAY 4	FCC	97	I04	I03	I0I	II5	I06	89	90	97	96	96
	AP MIN.	69	68	72	73	74	7I	72	70	68	66	67
	MID.	97	98	97	96	99	94	I03	I02	I04	I00	I03
	LAT.	II0	I06	I05	I07	II3	III	I20	II5	II6	II7	I20
	LIMB	I44	I43	I43	I38	I40	I42	I55	I52	I56	I52	I48
	PULS	4I	38	33	34	39	40	48	45	48	5I	53
	SV	96	6I	50	44	49	49	I03	I04	I09	IC8	I20
	MV	9.2	6.4	5.2	4,4	5.6	5.2	9.2	9.4	I04	I03	II.5

TABLE 21. RESULTS OF A TEST WITH LBNP ON THE OBE-2 (GLAZNOV)

TIME PERIOD	INDICES	BACK-GROUND	NEGATIVE PRESSURE MM MERCURY COLUMN					RECOVERY MIN				
			25	25	35	35	35	I	2	3	4	5
PRE-FLIGHT	FCC	55	56	54	54	56	50	55	55	53	54	50
	AP MIN.	59	56	58	57	59	56	63	65	65	63	70
	MID.	86	88	83	84	85	89	85	86	84	85	92
	LAT.	98	97	93	97	97	99	I04	98	98	I03	I05
	LIMB	I34	I25	I25	I26	I26	I26	I33	I3I	I36	I28	I33
	PULS	38	4I	35	40	38	43	4I	33	33	40	35
	SV	99	97	80	96	94	II7	I20	89			
	MV	5,5	5.4	4.3	5.2	5.3	5.8	6.6	5.0			
IN-FLIGHT DAY I2	FCC	78	86	82	9I	II4	II4					
	AP MIN.	65	62	63	60	6I	6I					
	MID.	99	95	99	96	98	96					
	LAT.	II7	I09	II3	I08	II5	II4					
	LIMB	I50	I42	I45	I42	I44	I45					
	PULS	52	47	50	48	54	53					
	SV	I38	-	II3	I0I	I07	I06					
	MV	I0.8	-	9.2	9.2	I2.2	I2					
POST-FLIGHT DAY 07	FCC	78	86	8I	95	94	95	69	72	72	65	7I
	AP MIN.	88	73	77	75	69	7I	77	73	75	75	75
	MID.	I0I	99	95	94	I04	95	I08	I00	I03	I00	I09
	LAT.	II3	II0	I06	I09	II2	I09	II8	II8	II7	III	II8
	LIMB	I4I	I33	I36	I38	I36	I32	I55	I52	I53	I42	I42
	PULS	39	37	29	34	43	38	4I	45	42	36	43
	SV											
	MV											
DAY 4	FCC	69	86	86	85	92	86	80	73	64	70	69
	AP MIN.	70	7I	7I	74	74	73	67	70	69	69	65
	MID.	95	I02	I02	98	I02	I03	93	99	98	I05	96
	LAT.	I09	II0	I08	I04	III	II4	II5	III	II2	II9	II9
	LIMB	I43	I33	I32	I28	I35	I4I	I50	I42	I45	I46	I43
	PULS	39	39	37	30	37	4I	48	4I	43	50	44
	SV	III	I0I	I0I	7I	I03	I02	I42	I20	I20	I35	I35
	MV	7.6	8.7	8.7	6.0	9.5	8.7	II.3	8.8	7.7	9.4	9.3

transferability of LBNP was noted in all the cosmonauts and a parallel to orthostatic stability was detected. Like worsening of orthostatic stability the decrease in transferability of LBNP was particularly marked in the OBE-1. It remained fairly marked in him even on day 17 postflight.

In the OBE-2, the transferability of LBNP was decreased up until the end of the first week. On day 14, full recovery had practically occurred both in the CDR-1 and the CDR-2.

Results of Clinical and Biochemical Studies /55

When carrying out clinical and biochemical studies the same changes were found which were observed earlier in other crews of orbital space stations.

In blood taken during cosmic flight on days 9, 17 and 38, a certain decrease in the ratio of leukocytes per 1000 erythrocytes was noted basically due to elements of brain hemopoiesis (neutrophils and basophils). At the same time, a decrease in the quantity of thrombocytes was noted (by 10-15%) and the number of reticulocytes was more noticeable (up to 25-40%).

Studies of the blood taken after 3-8 hours after landing showed a decrease in the size of the hematocrit in the second crew and an increase in the first crew. The quantity of reticulocytes and eosinophils decreased almost by half, the thrombocytes by 7-9%. The number of erythrocytes was somewhat increased (obviously, due to a certain thickening of the blood) and the amount of hemoglobin changed somewhat differently in different cosmonauts (Figure 5).

In the succeeding days, the readaptation period, the content of hemoglobin in the peripheral blood and the mass of hemoglobin in the organism gradually decreased up to days 14-15 (Figures 6 and 7). The size of the hematocrit in the first crew members began to recover in the second week; in the second crew it was only in the third week postflight. The number of erythrocytes, after the first week, began to increase and the number of reticylocytes in this time period reached a maximum, that is, a pronounced postflight reticulocytosis was observed (Figure 5). Then, with a shift left (full-reticular and powdered cells), this attests to irritation of the brain.

The picture of changes of the hemoglobin and cellular elements, especially the reticulocyte, contribute well to the hypothesis that due to the effect of factors of space flight, the - /59
rate of synthesis of hemoglobin was decreased and, correspondingly, the mass of circulating blood was decreased. In the period of readaptation on Earth, the reactive increase in the rate of synthesis of hemoglobin and erythropoiesis ensued. Due to the

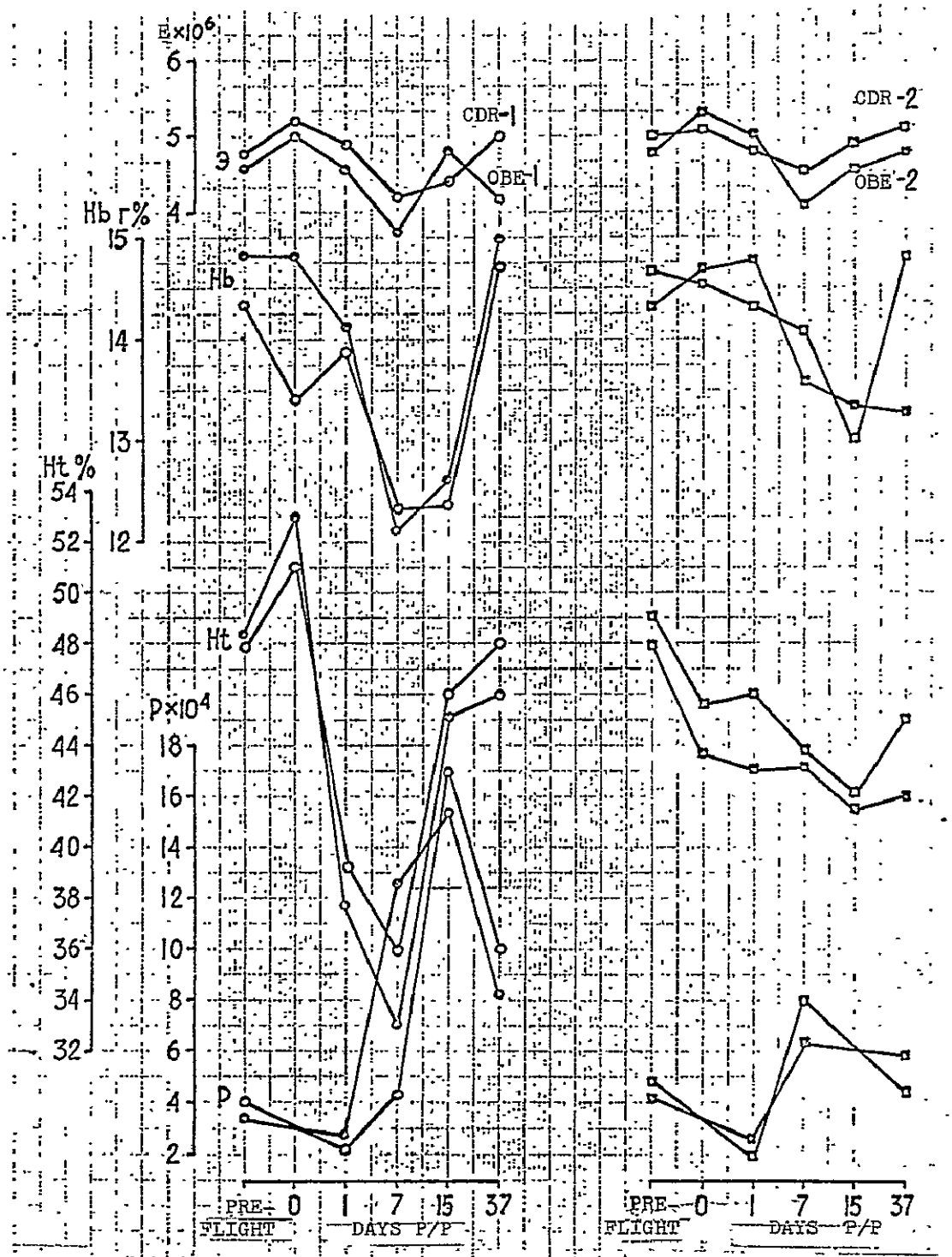


Figure 5. Dynamics of hematological indices: in the crews of the OPS, the Salyut-5 pre and postflight, along the axis of the ordinate: Hb--amount of hemoglobin in the blood in g%, E--number of erythrocytes in a µl of blood, Ht--size of the hematocrit/whole-crit/in %; P--number of reticulocytes in a ml of blood.

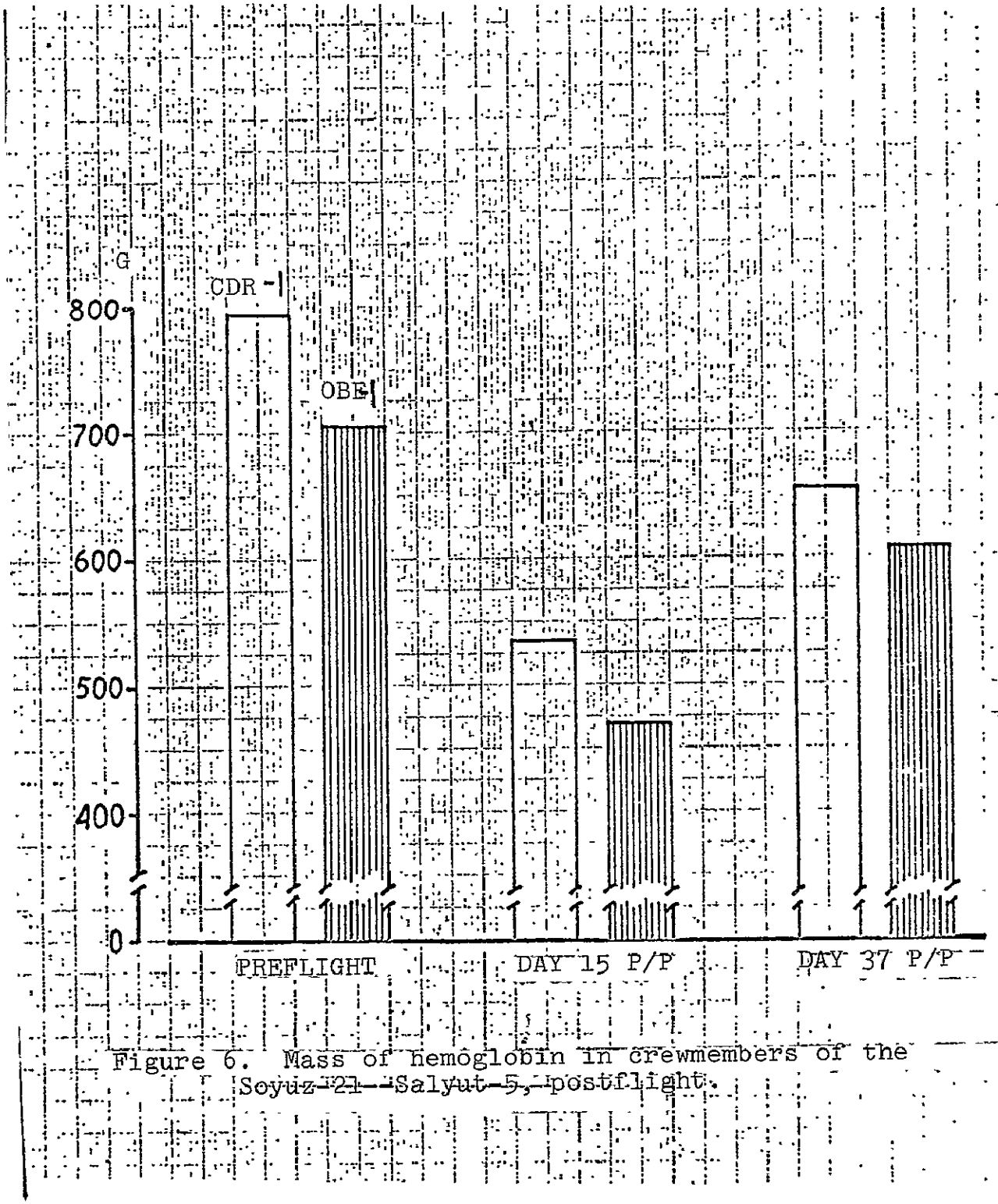


Figure 6. Mass of hemoglobin in crewmembers of the Soyuz-21--Salyut-5, postflight.

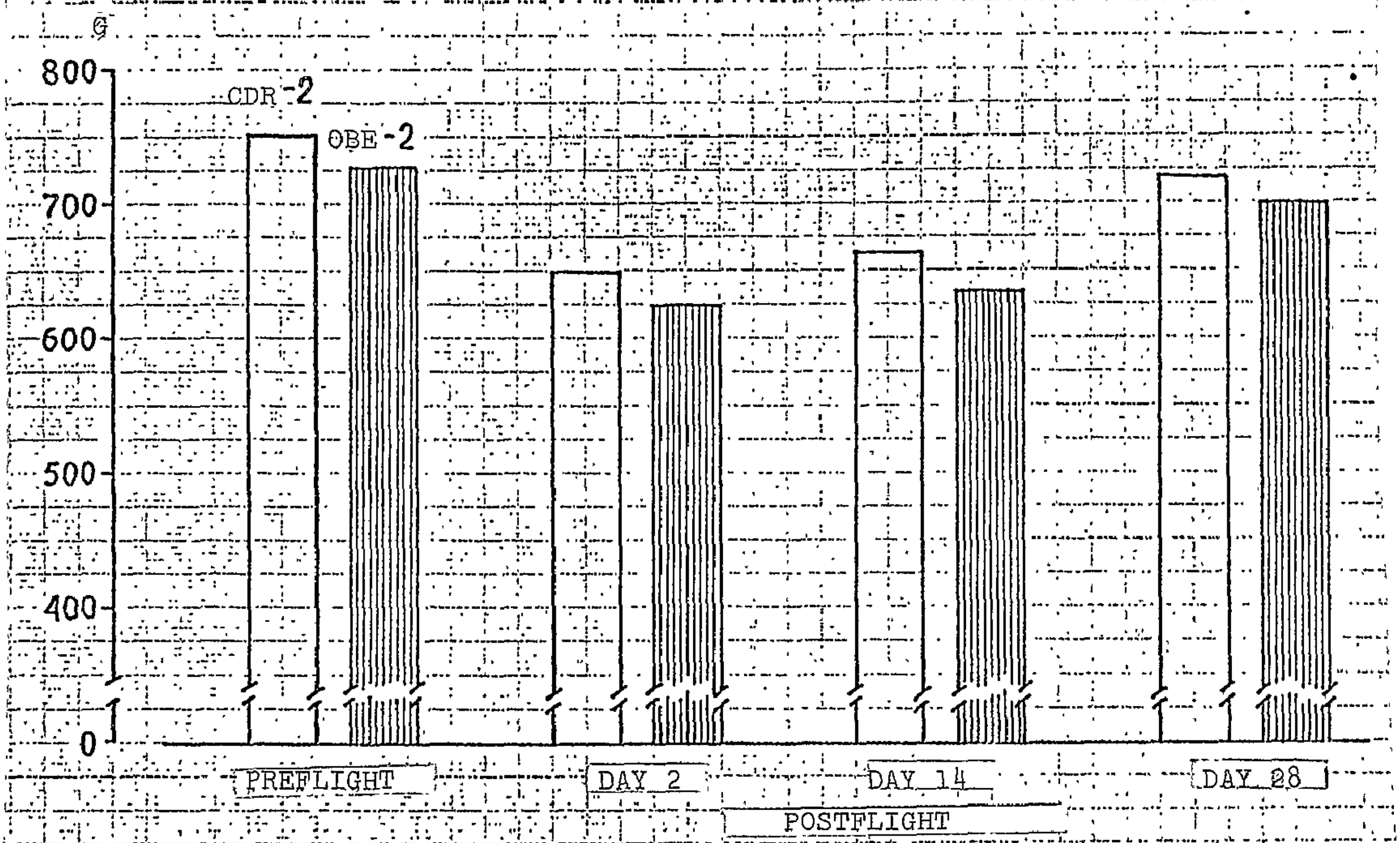


Figure 7. Mass of hemoglobin in members of the Soyuz-24 crew, postflight

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/58

delay in synthesis of the hemoglobin in meeting the requirements of the organism for blood, the "reserves" - young reticulocytes were ejected. Normalization of the Price-Jones blood and certain hematological indices ensued in week 3-4 and of others only after 1.5-2 months.

From the large number of indices studied, one should pay attention to the decrease in cholesterol in the CDR-2 and OBE-2 (by 9 % and 7%), and also to the increase on the first days of activity of muscular and hepatic enzymes (Figures 8, 9 and 10). Also the results of thymol tests were increased. Studies of the activity of isoenzymes 1 and 5 (cardiac and liver) of lactic dehydrogenases in members of the second crew showed their large relative increase in comparison with the total LDH, that is, the increase in activity of total LDH occurred due to isoenzymes. In the CDR-2, the shift of isoenzyme 5 (hepatic) was more pronounced and in the OBE-2--the cardiac enzyme.

At the same time, like the activity of the PC after a week, the LDH normalized after 2--3 weeks; the activity of sorbitodehydrogenase (SDH) continued to increase and on day thirty reached a size of 1.3-1.8 unit/ml. It is not impossible that after 14 days of the readaptation period, certain changes in the activity of the enzymes were due not only to the effect of space flight factors but also to disruption of the diet regime.

As was already pointed out, recovery of body weight occurred rapidly in the first 3-5 days (about 64%), and later on recovery was slower and took more than two weeks; in some of the cosmonauts it took more than a month. This, apparently, is due to atrophy /63 of muscular and other tissues in flight; the increase in the total blood proteins and the increase in the concentration of residual nitrogen in the blood indicates this.

Also, excretion of total nitrogen, phosphorus, sulphur, calcium, potassium, etc. from the urea increased. This all, undoubtedly, is due to change in metabolism of separate organs and tissues. We are reminded that after space flights, usually the content of cholesterol in the blood is decreased (sometimes by as much as 20%). In contradiction to this, in members of the second crew, the content of cholesterol in the blood was almost twice as high as preflight (243.5 mg % in comparison with 124.0 mg % preflight).

One should note that in these cosmonauts, in the first days postflight, that proteins (Figure 11) granular and hyaline cylinders, cells of the renal epithelium and erythrocytes were all observed in significant quantity in the urine, that is, symptoms of nephropathy were apparent. It is possible that this

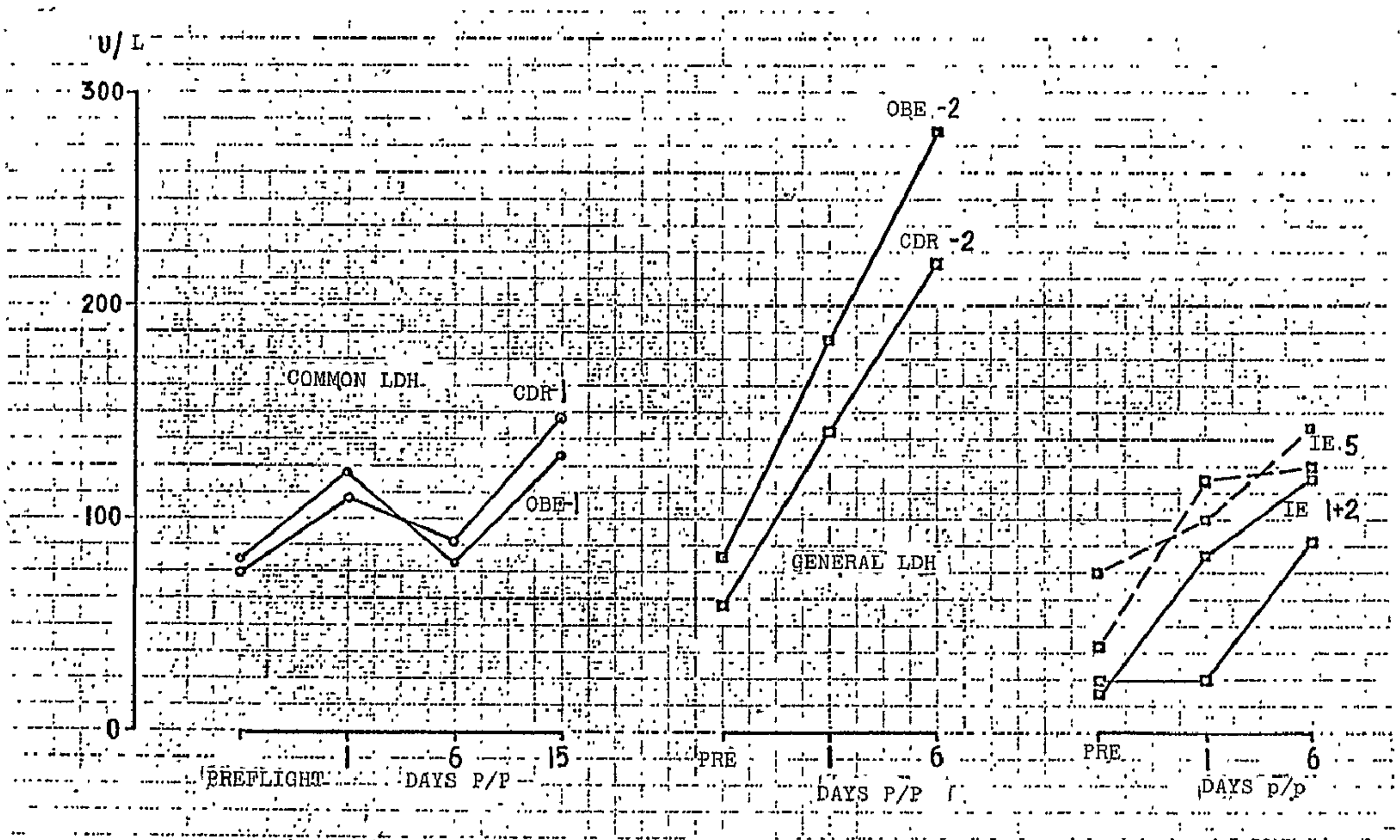

Figure 8. Activity of general lactic dehydrogenases (LDH) and isoenzymes 1 + 2 and 5.

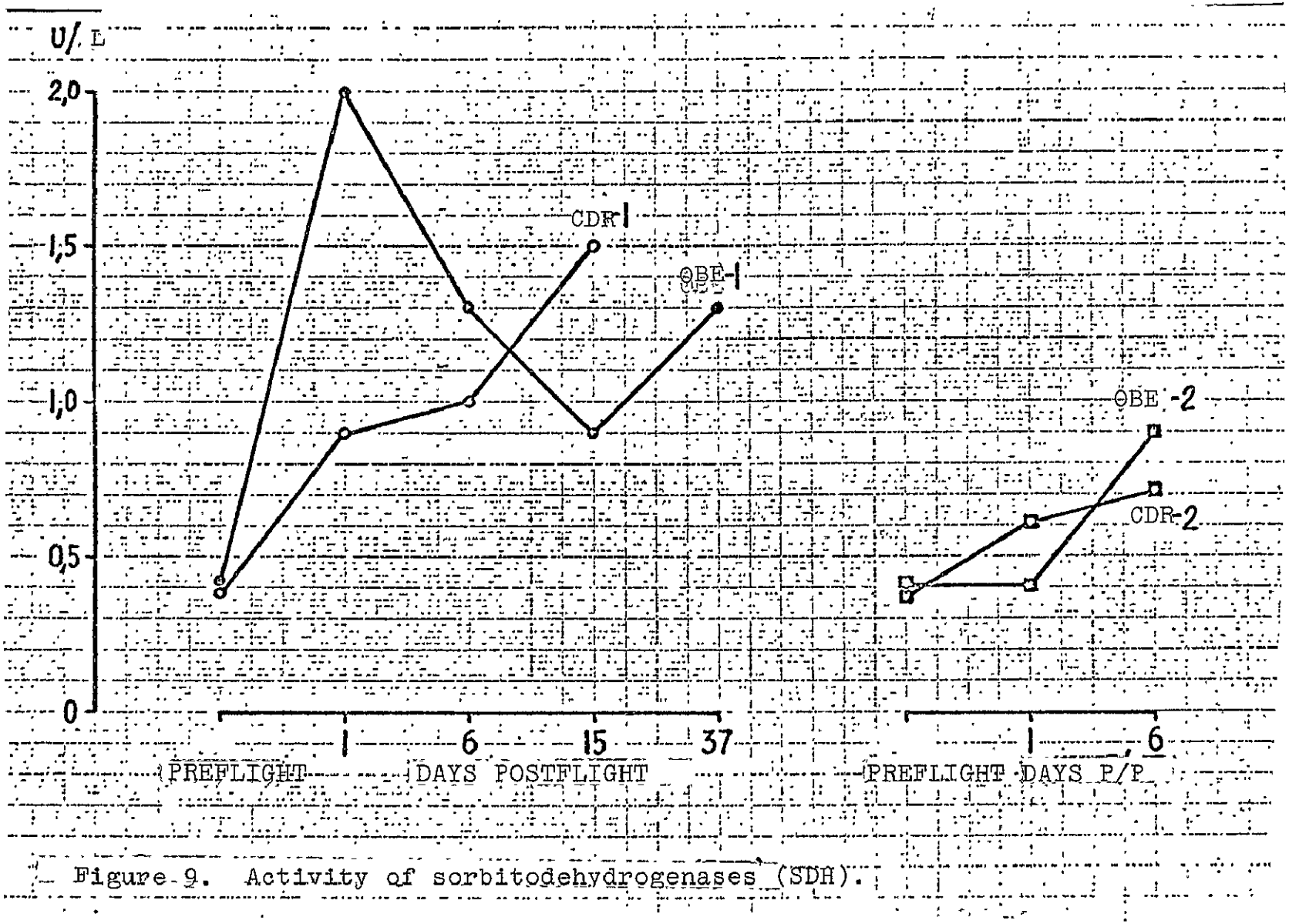

Figure 9. Activity of sorbitodehydrogenases (SDH).

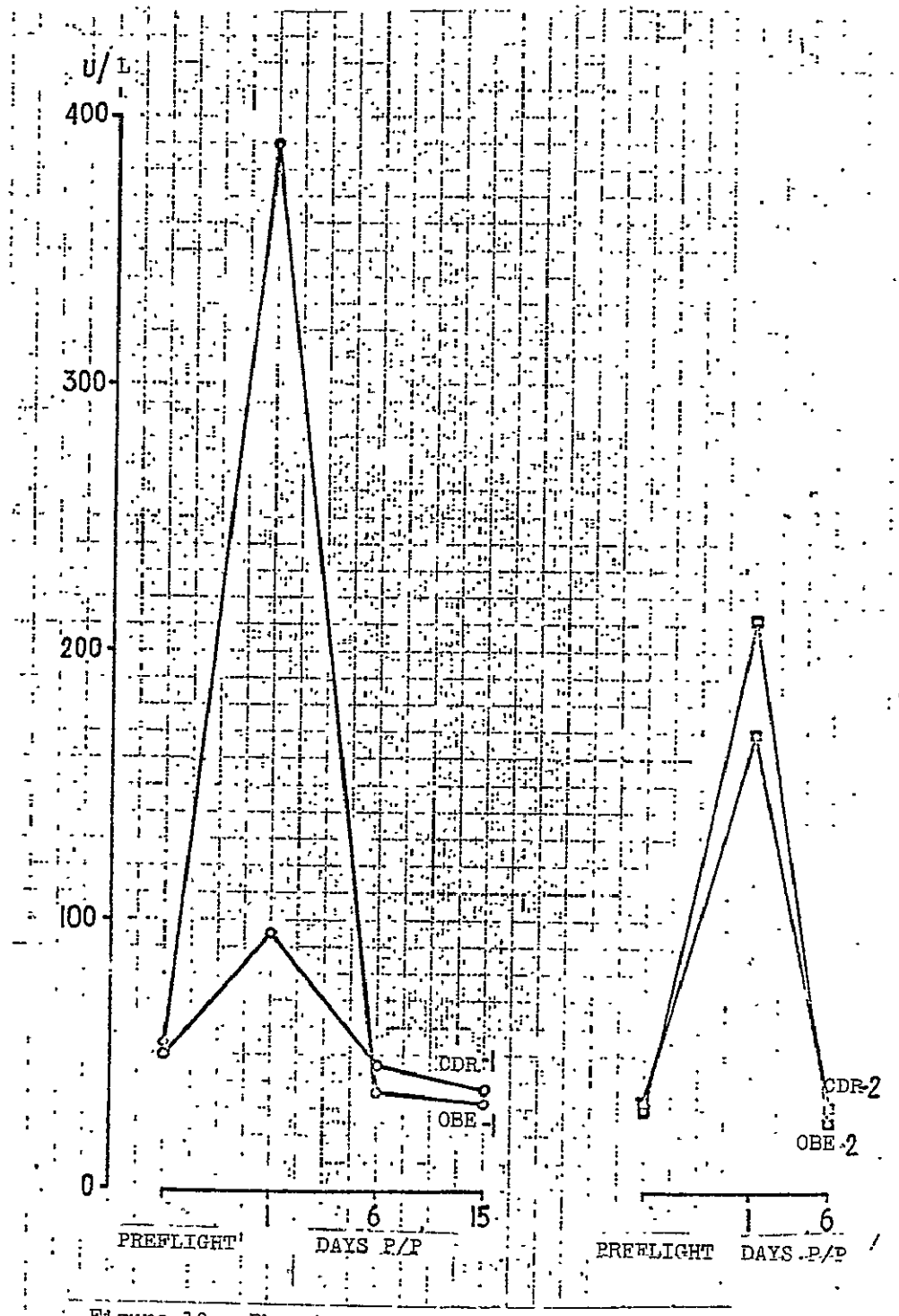

Figure 10. Phosphocreatinase activity (PC).

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/64

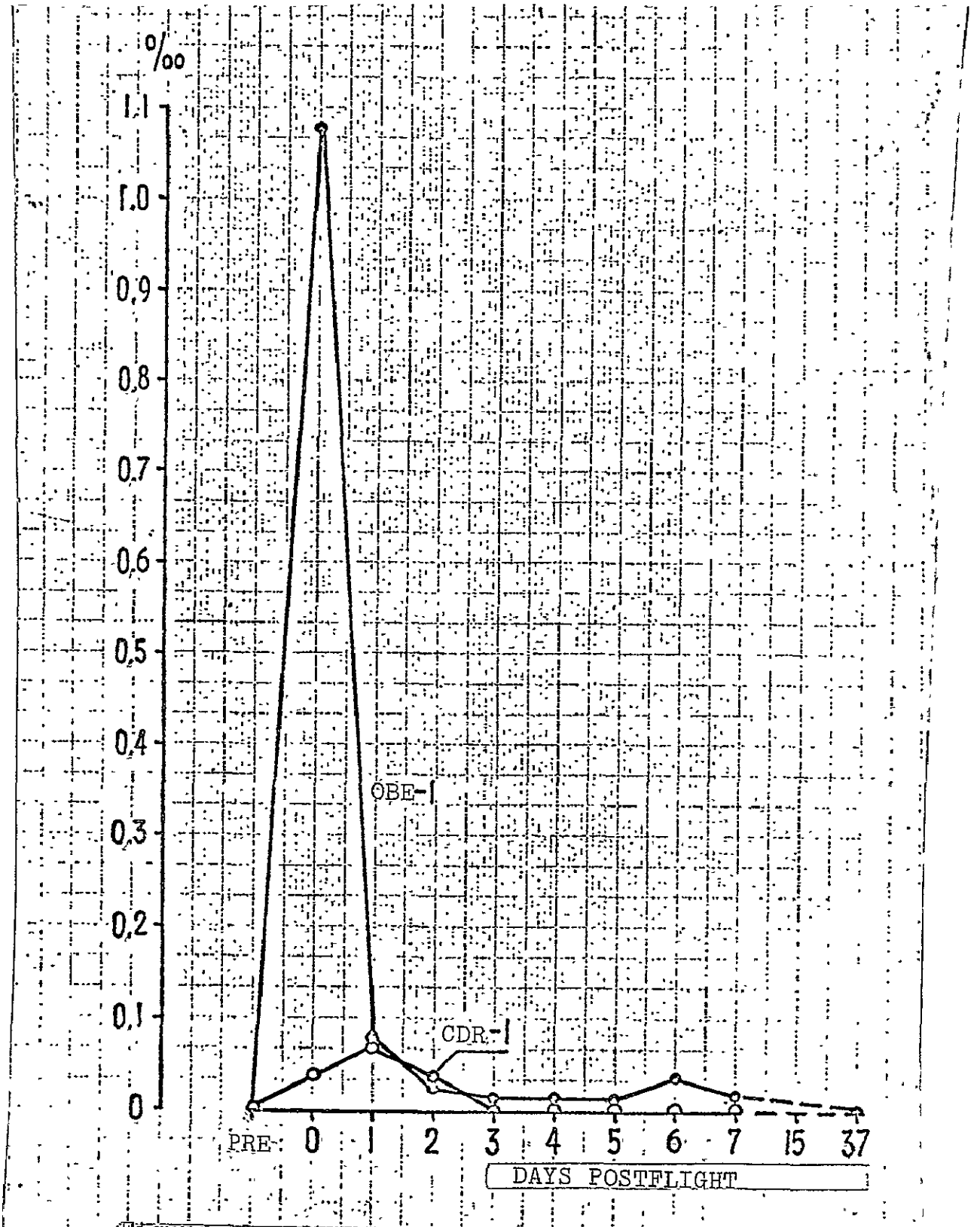

Figure 11. Dynamics of albuminaturia in the crews of the Salyut-5--Soyuz-21, postflight.

is closely connected to the increase in cholesterol in them.

The dynamics of generation of urine in the CDR-1 and OBE-1 in the first postflight days indicate that diurnal and nocturnal diuresis are almost identical (Figure 12) particularly in the OBE-1. This relationship indirectly supports the changes noted above in the cardiovascular system.

Excretion of epinephrine and noradrenaline increased to the upper limits of the norm and in the first days the content of aldosterone was increased. Generation of 17-oxicorticosteroids was within ordinary limits, but the relationship of separate fractions was changed. Marked changes in the nitrogen components were not observed. These studies also are new and therefore are not adequate statistically.

Study of corticosteroids of the urine using a thin-layer chromatograph indicated an increase in the specific quantity of predominant glucocorticoid hormones on a background of decreased generation of non-metabolized steroids; this is involved with the relative functional inadequacy of the adrenal cortex in developing steroid hormones. /66

Immunological Studies

After the flight, in all of the cosmonauts, as before, one observed a certain decrease in total and local immunological resistance of the organism. Restructuring of the microbe flora occurred, simplifying it, but at the same time, the number of complex-pathogenic strains increased. A decrease and elimination of lactobacilli and bacteroides was observed in the mouth cavity and in the intestine, and also the appearance of intestinal flora in the mouth cavity was observed. At the same time, the content of intestinal bacilli and enterococci in the intestine decreased.

In the first crew members, a positive reaction was noted to the C- reactive protein. In members of the second crew, this reaction was negative.

The content of immunoglobulins was increased, especially G, A, and M. Obviously, in connection with atropic changes in the skeletal musculature and muscles of the heart in the CDR-2, antibodies for the myocardium were found, that is, an autoimmunological process was observed. In members of the second crew, at the end of the fourth week, (by day 28) and in the first crew on day 37 (according to immunoglobulins A), the immune system was reestablished.

In this way, the results of the medical observations in

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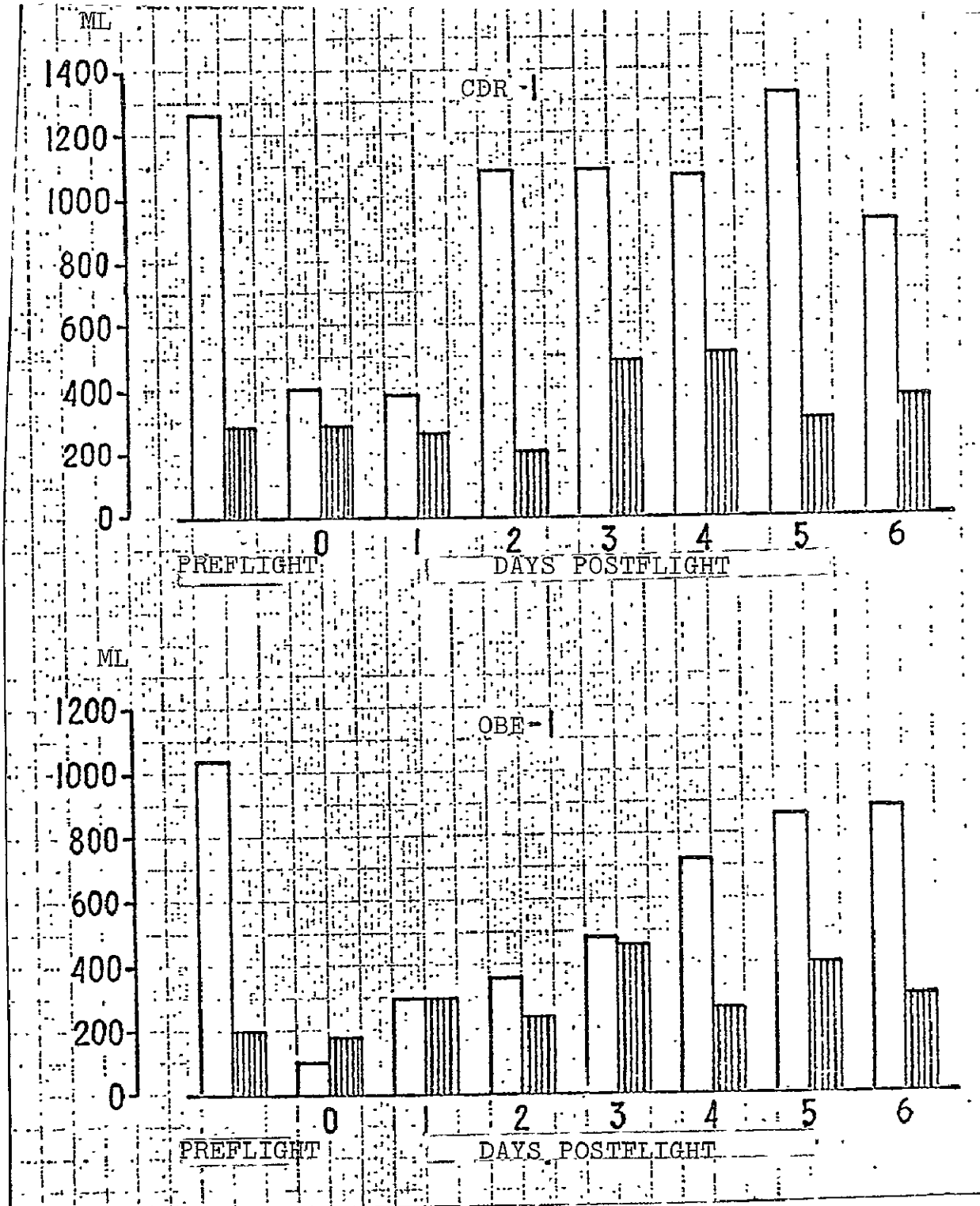

Figure 12. Dynamics of urine generation in the members of the Salyut-5 crew. Along the axis of the abscissa: 0--zero days, the number C+--days postflight, along the ordinate axis: indices of diuresis in ml.

studies made when preparing and accomplishing flights on the Salyut-5 orbital station, and also during the postflight observation of the cosmonauts, many data and general principles were supported which had been obtained in previous flights. Also, new facts were obtained relating to reactions of long-term effect of physical factors of space flight, living conditions and /67
stressful work activity. This brought about certain changes in the research program including the program of medical observations after flight.

The conclusion drawn earlier as to significant restructuring of the functional systems due to factors of space flight (particularly weightlessness) can be considered correct as a whole. A decrease in the reserve capabilities of the organism in flight was proven and the importance of strict observation of the work and rest regime was convincingly demonstrated as well as carrying out fully the planned physical exercises.

However, any questions require further, deeper and more detailed studies in order to increase safety of space flights, improve working conditions for crewmembers of spacecraft and space stations, maintain health of the cosmonauts as well as their professional work capability.